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SCHOOL SCIENCE AND MATHEMATICS

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PREPARATION OF THE TEACHER OF BIOLOGY.[1]

BY OTIS W. CALDWELL,

University of Chicago.

Since all students of education and most students of science agree that success in teaching biology depends more upon the teacher than upon the particular class of people to be taught, or upon the quantity and quality of laboratory equipment, the particular text to be used, or the social and economic conditions of the community to be served, it is evident that the question of teacher preparation is one of supreme significance to the welfare of biology as a subject of instruction. It is important to know the particular pupils to be taught, to have enough good laboratory equipment, to have reading material which is appropriate and accords with present knowledge of the science involved, and to know the peculiar social and economic conditions of the community to be served, but all of these are cared for in varying degrees of effectiveness according to the varying degrees of preparation of the teacher.

In the present elementary state of our knowledge of what constitutes the proper preparation of a biology teacher, few would claim that they have secured a full, or possibly even an approximate, answer to the question. Like most fields in which little scientific fact is known, one occasionally finds dogmatists asserting that certain procedures will give the correct result, one of the chief arguments for such dogmatic claim being found in the fact, not that the advocated procedure can be proved actually to produce the desired result, but that no one is able to show that the claims are not true. We cannot give a recipe, by means of which we may be sure to produce a good biology teacher. We

[1]Read before the Biology Section of the Central Association of Science and Mathematics Teachers, Harrison High School Chicago, Nov. 26, 1915.

can, however, point out some of the factors involved and these may guide our practice so that at some time we may be less uncertain of our results than we now are.

Recently the principal of a well-known high school said to me: "Upon the advice of your Bureau of Recommendations and the statements of those of you who had taught him, I recently secured a teacher of ——— science from your institution. I cannot keep him in my school, since he not only cannot teach his chief subject as it should be done, but he takes a scoffing attitude toward another science in which we asked him to take a class." It must be obvious that all who anticipate teaching biology, as well as those who are now teaching it, should understand the actual situation which prevails in public secondary schools. In Professor H. W. Josselyn's *Survey of the Accredited High Schools of Kansas* (July 1, 1914), it is shown that over sixty-eight per cent of all the high school teachers in those schools teach two, three, or four different subjects. Some of the combinations in teaching assignments reported by Professor Josselyn are as follows:

1. "Botany, domestic art, domestic science, physiology and modern history."
2. "Botany, physics, agriculture and solid geometry."
3. "Botany, English, civics, physiology, bookkeeping and history."

These are somewhat unusual combinations, and represent a teaching assignment which is undesirable, but while these are extreme situations, somewhat similar situations exist in every state. Professor Josselyn shows that the adjustment of high school teaching forces to the work to be done often results in assigning subjects to teachers who are not prepared to teach them, or in failing to assign teachers to the subjects which they are prepared to teach. The following figures indicate the extent of this failure to associate subjects with teacher preparation as shown in the Kansas study.

	Prepared and Teaching.	Not Prepared and Teaching.	Prepared and Not Teaching.	Total.
Physics	130	92	20	242
Physiology	19	57	8	84
Botany	71	74	39	184
Zoology	9	5	20	34
Physical geography	7	50	3	60
Agriculture	63	84	14	161
Domestic science	148	11	28	187
Totals	447	373	132	952

It may be argued that because this undesirable condition is an evidence of failure properly to administer the matters of high school organization, we should ignore these facts in our consideration of preparation of biology teachers. But similar conditions exist elsewhere as has been shown by various studies (Caldwell, *School Science and Mathematics,* 1909; Hunter, *School Science and Mathematics,* 1910; Robison, in a volume entitled *Agriculture in the Public Schools;* Eikenberry *School Review,* 21:542-548). In Eikenberry's study of "First-Year Science in Illinois High Schools," he finds most science teachers teaching more than one subject. In reports from 203 high schools he finds:

Number of teachers with two or more subjects in addition to first-year science, eighty-nine.

Number of teachers with three subjects in addition to first-year science, sixty-nine.

Number of teachers with four subjects in addition to first-year science, forty.

Number of teachers with five subjects in addition to first-year science, twenty-six.

Number of teachers with three or more subjects in addition to first-year science, 106.

It must be evident from the above data that the ambition to specialize in a single subject in biology, which is often entertained by some students, and usually encouraged by professional men, is not amply justified by the facts which these students must face when they actually enter teaching positions. Because of our ideals of specialized scholarship, we often encourage students to regard themselves as specialists in a single science, often in a single branch of a given science, and we often foster a narrowness which prevents even the specialist's studies from being as significant to him as those studies should be. The point of most import in this immediate connection, however, is that a secondary school teacher who takes a false view of his specialization, too often assumes an attitude of intolerance or almost contempt for related sciences to which his own specialty is inherently and organically connected. He thus loses the advantage for himself and his pupils of seeing the related principles and applications, and of allowing each science to help the other. The attitude is often such as to prove the old contention that there is no animosity so persistent as the dislike between those who are closely related.

It is to be hoped that high school administrators will see to it that science teachers are allowed to teach science, and not

required to teach mathematics, history, and the languages; but it cannot consistently be hoped that most secondary schools may have enough science teachers that each one may have his teaching time engaged in one science specialty. This fact makes one point clear—science teachers must be prepared to teach two or more science subjects.

To the biology teacher the above facts have still further significance. In high schools of five hundred or six hundred pupils, physics and chemistry more often occupy the full time of one teacher than is true of botany and zoology; hence there is greater need for the biology teacher to be prepared to teach more than two subjects.

The strongest reasons, however, for the wider preparation of the biology teacher are not found in the mere combinations of classes of students as shown in the above situations, but in the nature of the biological subjects to be taught. It would be difficult to prove that biological sciences in secondary schools have suffered more from extreme specialization than physical sciences, but it certainly is true that each group of sciences can make a strong claim to that questionable honor. But biological sciences, dealing with life, which varies with each new offspring of any living thing, with life which touches human interests and problems, with physical, chemical, and physiographic relations to living things, demand a measure of knowledge of sciences other than biological sciences, in order that biological problems themselves may be appreciated. The best teachers of biology have studied the elements of other sciences, so that they teach biology with the perspective which clears many cloudy situations. Furthermore, these related sciences give one security in added knowledge which serves as a bank surplus to give a drawing account or a feeling of security even in case the account is not actually drawn upon. Problems in biology are usually less exact than in physics and chemistry, but more complicated, and are far-reaching in the experience of pupils. Since they are far-reaching in human activity and in the range of scientific knowledge which they touch, the teacher's preparation should also be wider in its nature.

On the other hand, breadth of study without intensification would be as undesirable as the opposite extreme. It should be easily possible with our present college departments in almost any of our universities to provide an arrangement of courses which will secure adequate general courses in each of the requisite sciences and also to secure enough additional courses in one or two

subjects to give a more scholarly attitude in this more limited number of subjects. The teacher needs more extended scholarship in one or two differentiated fields partly that he may have a base line upon which to measure his more limited knowledge in other fields.

A brief examination of the plans recommended in departments of science in leading universities will indicate the present collegiate attitude toward teacher preparation in so far as teacher preparation is part of the purpose of these plans. The statements of the departments of science of the University of Chicago are taken as a type.[2] Comparison with statements from other leading universities will show similar results. It must be clearly understood that this analysis is not made in the spirit of unsympathetic criticism. The science departments discussed are probably not excelled anywhere in the quality of their work. The analysis is made solely with reference to the appropriateness of the plans of work when recommended as preparation for teaching. For purposes of comparison the recommended plans of departments of physics and chemistry are also given.

Thirty-six "majors" are required for graduation, a major consisting of one subject, which ordinarily requires one-third of the student's time for a period of three months.

I. Department of Physics.

Students preparing to teach physics are expected to take nine majors in the department of physics, and two majors of beginning college physics, or one year of high school physics must have been completed before beginning the nine majors of required courses. Therefore, in case high school physics has not been taken, eleven majors in college physics must be taken to meet the requirements. Of the nine majors (or eleven majors), one major may be in laboratory practice and discussions pertaining to teaching physics. Under certain circumstances candidates for the S. B. degree may substitute three majors from any one of the departments of mathematics, astronomy, chemistry, geology, or geography; but these are not included in the statement of courses required in preparation for teaching physics.

II. Department of Chemistry.

Students expecting to teach chemistry in secondary schools are expected to take "at least" nine majors in the department of chemistry. There is added the significant statement that "the prospective teacher in secondary schools should be prepared to teach at least one science beside chemistry," and it is advised that men make this other science either physics, mathematics, or geology, and that women choose the second science from physics, physiography, physiology, botany, or zoology." Assuming that the second science, if later to be taught, requires nine majors, which in nearly all cases are either distinctly required or so strongly preferred that the student feels that they are practically required, we find that these two sciences will have composed just half of the student's col-

[2] Data taken from circulars of information, April, 1915.

lege course. When consideration is made of the requirements of English, mathematics, history and the languages, and of the much-desired and proper elections in sociology, psychology, civics, economics, and education, it is evident that but little if any time remains for even general courses in the other sciences—astronomy, botany, zoology, bacteriology, and physiography.

Physiology.

Students preparing to teach physiology are told that they should take either seven or eight majors in the department of physiology and may complete their nine majors by adding one or two courses from the departments of chemistry, physics, histology, embryology, or plant physiology.

Zoology.

Students are advised to take nine majors in zoology, and undergraduate students "specializing in zoology should take four or five majors in chemistry, two or three in physics, and one or two in geology; they should also obtain knowledge of the general principles of microscopical anatomy, paleontology, botany and physiology." It is evident that undergraduate preparation in zoology is regarded as requiring a pretty long list of courses, at least part of these being distinctly technical in their nature.

Botany.

Students preparing to teach botany are expected to take nine majors of botany of which one may be in the teaching of the subject.

Physiography.

"Students intending to teach physiography in secondary schools" are required to take nine majors in the departments of geology and geography, and the only course in physiography given in either department is required as a prerequisite before beginning the nine major sequence, which is designed to prepare students to teach physiology.

In general, all the above departments encourage undergraduate students to take even more than nine majors in one department, some even reaching the university's maximum limit of fifteen majors in one department.

The types of requirements set forth by each of these departments can be explained by one or more of the following possibilities:

1. A failure to recognize the ordinary situations which teachers in secondary schools must face. That this possibility is true seems to be evident.

2. A belief that the best preparation for teaching two, three, or four subjects in secondary schools is secured by giving a large amount of academic training in a single subject. If this assumption is correct, it certainly has not been proved, and the burden of proof is upon those who make the assertion.

3. A belief that the undergraduate sequence in a department should be of such nature and extent as to give the student the technical preparation and subject-matter foundation which

will fit him for subsequent graduate research work in the subject. Indeed, in nearly all, if not all, the departments named, several of the courses required of undergraduate students may be taken and counted as graduate work by graduate students who come from small institutions in which these undergraduate courses are not offered.

It may also be urged that in the best positions in biology the teacher teaches *one* biological subject and that a considerable amount of technical work in that particular biological subject is helpful. It should be pointed out that in such positions the prestige and salaries paid are such as usually to command the services of those who have taken a master's degree in the subject, sometimes those who have a doctor's degree. Indeed, the present tendency is for the master's degree to become a teaching degree conferred upon those who, by efficiency in teaching and by graduate work in a chosen subject, have shown their special fitness for these especially desirable teaching positions.

We certainly shall find no fault with proper preparation for research in science. We all believe in research most profoundly, for true research is the highest ambition of most scientists. But biological teaching is an activity which has certain specific ends to be met, and these, if met at all, must be met under certain existing conditions which are now fairly well known. Preparation for teaching biology is a larger undergraduate task than preparation for research, since more students who prepare in biological subjects go into teaching than into research. Therefore, the courses of instruction for this larger number should face specifically the problems of preparation for teaching.

There have not been sufficient experiments in organizing separate courses and groupings of courses of instruction, to enable one to say just what is the best set of courses in preparation for teaching biology, but certain considerations are not to be overlooked, and these may prove to be fundamental. One consideration was illustrated recently when a successful school superintendent said, "I have found it best to select a high school science man from a small college in which there are one or two good general courses in each of the sciences." Such a science man is likely to have made a general study of each major science, and he has usually not gone sufficiently into any one to have lost the perspective of the beginning student. Also such a science man is likely to have done enough with each of the sciences to be taught in secondary schools to enable him to teach the elements

of the subject. Such a man often has need of more academic training in some of his subjects, and if he might have further academic training and still retain the point of view of the beginning student that would be greatly to be desired. If, however, it is a choice between an advanced scholastic attitude or of a beginner's intelligent inquiry, the latter will be the safer characteristic to place before young high school pupils. It is splendid to have scholarly teachers of biology and we all strive to secure them, but there is at present less danger of doing violence to the wonderful truths of biology than of doing violence to the educational development of high school pupils. It follows that the course of preparation should include general courses in each of the major sciences, enough in each to give a scholarly attitude toward the subject. It should also include courses not now given, courses which organize the uses which men make of science—horticulture, gardening, and agriculture.

Throughout this discussion it must have been clear that the preparation for teaching biology must include a study of the conditions in secondary schools, of the purposes for which biology is taught, and of the ways which successful teachers have found best in teaching the subject. During the past few years there has grown up a body of knowledge which relates to biological teaching. This body of knowledge differs widely from the methodology of the past decades, but consists of exact studies made in a scientific way regarding the problem of the use of biological subjects in education. Consideration of these matters cannot longer be safely omitted from the training of the prospective biology teachers. The waste in teaching efficiency and pupil opportunity will be great enough, even when all of the limited information now available upon biological teaching has been considered. Furthermore, this field offers quite as large an outlook for scientific research as do strictly academic fields.

Such a program of rearrangement of collegiate training for those who are to enter biological teaching is quite possible within the range of college years as they now stand. But this program involves a frank recognition of the kind of scholastic and professional training needed by high school teachers of biology.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS REPORT OF THE COMMITTEE ON A FOUR-YEAR HIGH SCHOOL SCIENCE COURSE.[1]

BY OTIS W. CALDWELL, *Chairman*,
University of Chicago.

During the three years since the appointment of the committee, its work and its reports have constantly kept in mind the needs of the whole science situation in secondary schools. In the first committee report presented at the 1913 meeting, recommendations were made regarding the science situation as a whole. With the plan as a whole in mind, it was obviously necessary to begin more intensive work in the first course included in the plan, and last year's report dealt with the point of view which it was thought should prevail in the first year's work. At last year's meeting of the Association, it was voted that the committee prepare for this year's report a somewhat more detailed investigation of the actual situation of general science as a first-year high school subject. The committee understands that this emphasis upon first-year work is because of the necessity of discovering the best types of science work for the beginning of high school training, and not in any sense as evidence that the sciences of the other years of the high school are to be neglected.

The Chairman of the committee undertook to discover the facts regarding some of the questions related to first-year science. Part of this work was carried on by a graduate student, Miss Aravilla Taylor. It was decided to find out to what extent general science is being used in two representative states, one in which it was known that the subject had been taught in at least a few schools for several years, and another in which it was thought that general science is now being introduced. California and Iowa were selected as these two states, and data were collected covering the school year 1914-15. Further data are now being collected from Massachusetts, but this added inquiry, but recently undertaken, has not been completed. It is expected that the Massachusetts data will be available for report and publication early in 1916.

Letters were written to the four-year high schools in both of the states mentioned. The following table gives the number of letters sent and the response from schools of different sizes, also the totals for all schools in each state.

[1]Read before the General Meeting of the Central Association of Science and Mathematics Teachers, Harrison High School, Chicago, Nov. 27, 1915.

Enrollment of the High School, 1913-14.	No. of letters. Iowa	Cal.	No. of Answers. Iowa.	Cal.	No. having General Science. Iowa.	Cal.
200 plus	40	55	30	50	11	25
100-199	87	53	61	47	11	28
50- 99	71	71	44	61	9	27
49-	30	46	18	38	2	19
Total[2]	228	225	153	196	33	99

Of 228 schools in Iowa to which letters were sent, 153 reported and of these thirty-three were teaching general science last year. Of 225 schools in California to which letters were sent, 196 reported, and of these, ninety-nine were teaching general science.

In Iowa, general science was given in but one school in 1911, three in 1912, nine in 1913, and twenty in 1915. We are told by an Iowa State School officer that the number of schools offering general science in 1915-16 greatly exceeds the number of 1914-15, but more exact information on that point has not as yet been secured. Another inquiry is now being made to determine to what, if any, extent the situation in the same schools in Iowa has changed in 1915-16 as compared with 1914-15.

In California, the first course in general science was taught in 1906, and seventy-nine of the ninety-nine schools which report courses in general science introduced the subject between the years 1910-14.

In both states, a strikingly large number of schools reporting are in favor of giving a first-year course in general science, although for one reason or another, they may not have introduced the work. In Iowa, of the 153 reporting, 103 favor the introduction of the course, thirteen oppose it, and thirty-seven did not give an opinion. In California, of the 196 schools reporting, 155 favor a course in general science, twenty-seven oppose it, and thirteen do not give an opinion.

Of the thirty-three Iowa high schools which taught general science last year, all but two offered the subject in the first year of the high school. In California, ninety-seven of the ninety-nine schools offered the subject in the first year, and two offered it in the second year. In both states, there is in some schools a tendency to allow pupils from the second year to take the subject along with first-year pupils, but this tendency would disappear after all first-year pupils once had taken the subject.

In Iowa, twelve of the thirty-three schools offered general science as a full-year subject, and twenty-one as a half-year sub-

[2] A preliminary summary of the Massachusetts investigation gives the following: From 222 schools to which letters were sent, 150 replies have been received, and 133 of the 150 are teaching general science. Further replies are expected.

ject; in California, eighty-two as a full-year, and eight as a half-year, nine of the schools not giving information on this point. In Iowa, twenty-nine of the thirty-three schools give five hours per week to the subject. In California, nineteen give seven hours, nineteen give ten hours, six give eight hours, eight give five hours.

In Iowa, thirty of the thirty-three schools give laboratory work as part of the course. In California, ninety-eight of the ninety-nine give laboratory work. From the two states, of the 131 schools offering general science, but three schools give neither laboratory nor field work as a part of the course.

From the two states, of the whole number of 132 schools offering general science, the other sciences displaced by general science are as follows: No subject displaced, seventy-seven schools; physical geography, forty-one schools; botany, three schools; zoology, two schools; Latin, three schools; physics, one school; commercial geography, one school.

The combinations of subjects taught by the general science teachers represent in one school or another every other subject included in the high school curriculum.

The reasons given for continuance of the general science course are included in the following statements. It is to be understood that not all made the statement in exactly the wording here given, but the statements are so nearly the same that this wording is valid for all.

Sixty-five state: "The subject is fine for those who take no other science, because it lays a good foundation and makes the pupils familiar with scientific method."

Thirty-five state: "Subject is fine for those who take no other science in later years, or those who leave school early, because it gives valuable general information."

Eight state: "It stimulates desire to know more science."

Twelve state: "It holds the interest of pupils."

Twelve state: "Pupils are much interested by it."

Six state: "Proper preparation for agriculture."

Seven state: "Practical and adapted to local needs."

Seven state: "Explains common phenomena without too much detail."

Six state: "Causes pupils to observe and think."

Five state: "Has human interest and great educational value."

Four state: "Good for all, gives survey of the whole field."

Two state: "Holds boys better than any other subject offered."

Two state: "Reaches a lot of pupils with general science knowledge —pupils who are not otherwise reached."

Two state: "Keeps pupils in school."

Reasons for general science that were stated by not more than

one school are not included, though many of these reasons are interesting.

Of those who give objections to the course, the largest number giving any one reason is thirteen who state:

"The course is poor because of lack of prepared teachers and good texts."

Nine state: "The course is too general."
Eight state: "It lacks the unity and continuity of a basic subject."
Seven state: "It is a smattering of everything."
Five state: "Physiography is more definite."
Four state: "With agriculture, we do not need it."
Two state: "Colleges do not credit it."

Another line of investigation has been undertaken in an attempt to determine the actual and relative amounts of science taken in high schools both before and after the introduction of general science. Type schools in which general science has been taught for as much as four years prior to the present school year were asked for numerical data bearing upon this question. Blanks upon which the desired information was to be recorded were so arranged that the numbers of students in each science during each year could be recorded in a definite way. The nature of school records in different schools is such that there are possible sources of error in the data, but they are as accurate as careful attention could make them. The figures requested covered the following points:

1. Number of pupils in the high school during each of the four years immediately preceding the introduction of general science.
2. Number of pupils in the freshman class in each of the above years.
3. Number of pupils in each science in each of the above years.
4. The sciences which were elective and which were required in each of the above years.
5. Number of pupils graduated in each of the above years.

The schools were asked to supply the same data for the years since the introduction of general science, a separate blank being provided for the latter period.

Three schools supplied the desired data for the four years immediately preceding the introduction of general science, and four schools supplied data for the past four years. Some of these schools supplied data for longer periods, but since the past four years are the only ones for which all four of the schools supply the data, these four years are the ones included in this report. A study of data for other years as given by two schools shows no

CHART I.—Record for Four Years Preceding Introduction of General Science

Year.	Pupils in High School.	Pupils in Freshman Class.	Number Graduating.	Physiography, or Physical Geog.	Physiology.	General Biology.	Botany.	Zoology.	Physics.	Chemistry.	Domestic Science.	Other Sciences.	Total Science Registrations in Each School.	Percentage of Science Registrations in Each School.	Percentage of Science Registrations in All Schools for Each of Four Years Preceding General Science.	Percentage of Science Registrations for Four Years Combined.
1905-06, P. H. S.[2]	321	224	Not given	0	62	0	184	34	34	29	0		343	106.8		
1904-05, U. H. S.	565	126	61	73	0	14	0	0	51	59	21		218	38.5	68.2	
1903-04, M. H. S.	640	252	73	90	35	35	69	0	198	46	0	Geol., 8	481	75.1		
1906-07, P. H. S.	342	252	Not given	0	64	0	205	20	26	30	0		345	100.8		
1905-06, U. H. S.	561	175	49	130	0	13	0	0	75	18	18		254	45.2	69.4	
1904-05, M. H. S.	702	291	84	105	27	27	72	0	205	63	0	Geol., 16	515	73.3		68.8
1907-08, P. H. S.	368	278	Not given	0	61	0	209	20	27	42	0		359	97.3		
1906-07, U. H. S.	641	161	79	73	0	17	0	0	77	27	22		216	33.6	66.4	
1905-06, M. H. S.	698	255	83	106	32	32	64	0	219	83	0	Geol., 24	560	80.2		
1908-09, P. H. S.	402	300	Not given	0	61	0	209	20	28	42	0		360	89.5		
1907-08, U. H. S.	600	159	79	112	0	0	81	0	97	36	39		315	52.5	71.4	
1906-07, M. H. S.	726	285	107	80	41	41	68	0	223	79	0	Geol., 27	559	76.9		

• Average year—1906.

In U. H. S., years 1908-1910 omitted from these data, since in those years a half year each of physiography, botany, physics, and zoology was taught as a two-year course. This plan was then discontinued in favor of one year of general science followed by full years in differentiated sciences.

Data for the Oak Park High School, which school is included in the next chart, are not available for the years preceding introduction of general science.

[2]P. H. S.—South Pittsburgh High School.
U. H. S.—University High School.
M. H. S.—Malden, Mass., High School.

CHART II.—Record for Four Years Following Introduction of General Science

(Last Four Years Included)

Year.	Pupils in High School.	Pupils in Freshman Class.	Pupils Graduated.	General Science.	Physiography, or Physical Geog.	Physiology.	General Biology.	Botany.	Zoology.	Physics.	Chemistry.	Domestic Science.	Other Sciences.	Total Science Registrations in Each School.	Percentage of Science Registrations in Each School.	Percentage of Science Registrations in All Schools for Each of Four Years.	Percentage of Science Registrations for Four Years Combined.
1912-13, P. H. S.	408	247	32	248	24	9	150	10	0	40	84	24		589	146.8		
1912-13, U. H. S.	506	114	101	55	12	0	0	25	14	58	23	59	Com. geog., 35	281	68.8		
1912, M. H. S.	985	324	159	309	34	102	27	75	0	58	74	27		706	70.6		
1912-13, O. H. S.	1017	362	154	362	17	0	0	14	16	35	75	0		519	51.0	71.1	
1913-14, P. H. S.	483	233	65	182	18	20	137	0	11	43	192	48		651	132.7		
1913-14, U. H. S.	407	87	91	41	19	8	0	17	17	36	33	67	Com. geog., 46	284	69.7		
1913, M. H. S.	1066	480	123	304	21	128	24	25	0	45	48	16		611	57.3		
1913-14, O. H. S.	1070	368	155	368	9	0	0	14	11	63	65	58		588	54.9	70.5	
1914-15, P. H. S.	632	303	75	286	24	22	147	0	0	52	154	34		719	113.7		
1914-15, U. H. S.	411	125	97	66	13	0	23	22	0	53	24	64	Com. geog., 36	301	73.2		71.5
1914, M. H. S.	1155	502	132	431	0	157	19	11	0	77	56	12		761	66.0		
1914-15, O. H. S. (First one-half year)	1166	440	154	440	23	0	0	19	19	48	64	58		671	57.5	72.9	
1915-16, P. H. S.	805	348	......	247	0	27	100	0	0	41	177	27		619	76.8		
1915-16, U. H. S.	425	120	......	67	0	27	17	21	0	40	34	50	Com. geog., 15	269	63.2		
1915-16, M. H. S.	1189	420	......	292	0	385	16	11	0	86	88	21		899	75.6		
1915-16, O. H. S.	1230	495	......	495	22	0	0	23	24	72	94	56		786	69.5	70.5	

Average year—1914.

Oak Park reports that one and possibly two more classes in biology could have been organized this year, 1915-16, had there been sufficient available teaching force.

Agriculture is not given in any of the four high schools.

P. H. S.—South Pittsburgh High School.
U. H. S.—University High School.
M. H. S.—Malden, Mass., High School.
O. H. S.—Oak Park, Ill., High School.

essentially different results from those shown in the past four years.

It is clearly recognized that four schools, including an average of 3,239 pupils in each year during the latter four-year period, is quite too small a number upon which to base conclusions. Although conclusions may not be safely drawn from this small number, the results here shown are suggestive. In the first chart, in which the average date is 1906, the average annual percentage of registration in science is 68.8 of the average annual number of pupils in all the schools. In the second period, in which the average date is 1914, the average annual percentage of registration in science is 71.5. When the fact that in these schools the percentage of registration in science is slightly increased is associated with the fact that between 1906 and 1914 there was a great increase in the number of pupils in the high school (an average of 1,641 per year in the three schools in the first period as compared with an average of 3,239 per year in the four schools in the second period), it becomes evident that there has been a great increase in the actual number of pupils taking science. If, however, the number taking general science in the second four-year period is omitted from the total science registrations, it appears that there has been a slight reduction in the registrations in science other than general science. A further study of the registrations in each science will show whether the absolute numbers have increased or decreased, but the number of cases shown in but four schools is too small for such analysis to show conclusive results.

In closing this report, we wish to say that it seems wise for the Central Association of Science and Mathematics Teachers to have a perennial Committee on the Four-Year High School Science Course, but that annual reports should not be given unless the year has produced sufficient experimentation to justify a report, or unless there are matters upon which the committee or members of the Association desire to see experiments initiated. The committee should serve to bring before the Association from time to time the results of efforts to improve science teaching, also to bring before the Association topics relating to science teaching, or plans for experimentation which it or members of the Association regard as important for use in the unification of high school science.

A. W. Evans, *Chicago, Ill.,*
W. M. Butler, *St. Louis, Mo.,*
James H. Smith, *Chicago, Ill.,*
C. E. Spicer, *Joliet, Ill.,*
Otis W. Caldwell, *Chicago, Ill., Chairman,*

A DISCUSSION OF A REPORT OF A CHEMISTRY SURVEY.[1]

By S. R. Powers,
Garfield High School, Terre Haute, Ind.

This report is not offered as a final word on any of the points here considered. We were criticized for attempting such an exhaustive survey. We hope, however, that we have opened some important questions and that it will be possible to give further study to some of the points which this report leaves up in the air.

Some of the conditions under which we worked while sending out the questionnaire were quite adverse. First, it was impossible to get the names of the chemistry teachers throughout the different states, and also impossible to determine what cities taught chemistry in their high schools. The best we could do was to pick out the fair-sized towns and mail the blanks to the chemistry teacher in care of the high school principal. No doubt some of them failed to reach the teacher after being delivered to the building and unquestionably many were mailed to high schools in which chemistry is not taught. Second, the funds available did not allow us much for postage and the blanks were sent unsealed with a one-cent stamp. Also, a large number were sent to distant states and we could hardly expect the same interest in things geographically remote as in things close at hand. With this in mind the fact that we received only one reply for every 6.7 sent out does not seem so discouraging.

There seems to be a fair agreement among chemistry teachers concerning the allotment of time to laboratory and recitation work. I wonder if there is a real belief on the part of chemistry teachers that the double periods twice per week for laboratory and single periods three times per week for recitation are best, or if this arrangement is an outgrowth of a conflict between principal and chemistry teacher. By this method two sections may be cared for in three program hours while daily double periods require four. I know in my own case the conflict is still raging and will continue to rage until I am allowed daily double periods for each class. I was not able to determine the exact number that had daily double periods but it was not many more nor less than twenty-two. The difference between the advantages of having laboratory work on alternate days and on consecutive days is probably very slight, aside from the advantages gained in making the high school daily program. A greater number have the laboratory work on alternate days.

[1]Read before the Chemistry Section of the Central Association of Science and Mathematics Teachers, Harrison High School, Chicago, Nov. 27, 1915.

There are many principals, it seems, who fail to recognize the chemistry teacher's need for an hour sometime during the day to handle the apparatus and materials.

Chemistry is placed in most schools as an elective science and is considered more a senior than a junior subject.

Most schools seem to have about all that could be desired in the way of equipment. It seems though that quite a number have not yet emerged from the closets and basements to which chemistry was relegated in its earlier days.

Considering the large number of schools in which chemistry is entirely elective, the patronage is all that could be hoped for. A good deal is being said just now about the patronage of high school science courses being on the decrease. If the statement is made that the cause of this decrease is due to lack of popularity, the replies to this report would surely make the truth of this statement questionable so far as chemistry is concerned.

The figures giving the cost of the course in chemistry per pupil per year were derived by dividing the number of dollars for annual allowance by the number of students taking chemistry. The very high figure derived in a few cases might indicate that the question had been improperly interpreted. Such difference of opinion leads me to believe that it would not be unwise for this Association to establish a figure which would represent a reasonable cost per pupil for chemistry. Such a figure would be especially valuable to beginning teachers. An expression from the Association concerning the advisability of charging a laboratory fee to cover all or part of the cost of breakage and chemicals used might also be valuable.

The forty-three schools mentioned as having fair chemistry libraries are the only ones having libraries worthy of mention. The list of reference books given would undoubtedly make an excellent three-foot shelf.

Chemistry teachers usually seem to have excellent preparation for their work except possibly from the standpoint of professional training. Although ninety-five report having devoted some time to study of methods of teaching, in a great many cases this was indeed a very small amount.

Replies to the question of years of service would seem to indicate that chemistry teachers are not transitory.

The replies to the question concerning number of students in each class are not reliable without a word of explanation. Although ninety-six have less than twenty-four students in any class,

a large part of this ninety-six have less than twenty-four because of lack of pupils. In larger schools the tendency is to crowd the classes.

Chemistry teachers seem to have remarkable ability as athletic coaches. The reason probably lies in the fact that more men are engaged in teaching chemistry than in most any other line.

It seems that only a few of the teachers avail themselves of the opportunity of using their students for assistance in the laboratory. A few arrange to pay students for rendering assistance, some allow credit toward graduation for this kind of work, and others simply ask for assistance from different students as they are able to use them. In my own experience I find students usually willing and anxious to spend extra time in the laboratory assisting me in cleaning up, and I think it invariably true that those who spend time with me in this way take greatest interest in the work. The converse of this is also probably true, namely, that those most interested are most willing to assist. Certainly there are opportunities here that more teachers might avail themselves of.

In general, a larger amount of the teacher's time is devoted to library study in preparation for the work and to the preparation of laboratory material and a lesser amount to cleaning up the laboratory and reading notebooks. This is undoubtedly as it should be. A question with many of us is how to get along and yet spend less time on reading notes. This is not necessarily because this form of work is unpleasant, but because we fear it is unfruitful. We fear that the student does not get the greatest amount of good from our time if it is spent in this way. The chemistry teacher should be constructive and should be working for new and original methods of teaching his subject. This is impossible if a large amount of his time is consumed in reading notes. Several teachers seem to have methods for reducing the time spent on notebook reading to an insignificant item. Please tell us how you do it. When do you read the student's notes? If you read them during the laboratory period, what kind of preparation do you make for your laboratory classes? What kind of equipment do you have? Etc.

The most common methods of training in neatness are by setting proper example and by continually calling the subject of neatness to the attention of students. Twenty deduct from grade for lack of neatness on the part of students. Do these practice legitimate pedagogy?

The replies indicate considerable disagreement concerning the proper method of approach to a new subject. If there is a correct or best method, many teachers do not know what it is. The question of which should receive greater attention, text or laboratory, is one about which there is a wide difference of opinion. The large number of teachers who draw material from more than one manual, and the large number who write part or all of their own laboratory directions, indicate a general dissatisfaction with the manuals now on the market. This is as we should expect in a subject, the methods of teaching which are so rapidly changing, and seems indeed quite encouraging to those interested in the advancement of our science in the high school. For although there is a wide difference of opinion upon the question of what is right or best, teachers are on the alert, continually tussling with the problem, and looking for the best there is in their line.

If chemistry teachers were dominated by university and college syllabuses, there would not be such a variety of answers to the question referring to number of pages covered during a semester. Certainly, some of the teachers are mistaken about the range of subjects which should be presented. While we should be proud of the fact that we are at liberty to present such chemical material as we see fit, yet in a course which offers such a variety of material as chemistry does, a suggestive syllabus which we as a body might agree upon would certainly be valuable in assisting us to make a choice of material for our course. About the same amount of difference of opinion exists in regard to the method of presenting laboratory work. If we were to investigate the methods used by arithmetic or history teachers throughout the Central States, it is pretty certain that there would not be found as much difference in method of presenting or content of course as exists in chemistry. Our normal schools agree in general on the method for arithmetic and history, and as we pass through them we absorb from their classrooms that method. It is needless to say that chemistry teaching has not been thus standardized and each chemistry teacher either works out his own method independently, with but little suggestion or aid from any source, or carries over into the high school the method that was used in his college or university course. The laboratory, especially, is a place where many beginning teachers and some others do considerable floundering and any instruction which those who have been more successful might give would certainly be valuable. Since these conditions seem to exist, it might be advisable for this Association to take some steps

toward standardizing the method of teaching, as well as the content of the chemistry course.

The thought in the mind of the writer concerning definite units and continuity of laboratory exercises is no doubt vaguely expressed in the questionnaire blank. Many of the replies, however, indicated that there was food for thought in the suggestion. The exercises as they are written seem to be planned for a two-hour period rather than for anything else. The exercise completed in a day is a unit of itself and it is difficult to show that this is related, directly or indirectly, with the work of the preceding day. The other alternative would be to make the exercises on a given subject continuous; and interspersed with explanatory matter and references to textbooks on the subject investigated. Many teachers devote a large amount of the recitation time to discussion of the laboratory work and many prefer to make the laboratory the nucleus around which the course is built. We are of the opinion that the laboratory work should be given greater prominence but with the book writers, who plan our course, giving greater prominence to the textbook, it is a little hard for us to adjust ourselves to the method we think we ought to use. A treatment of a unit of work as a unit rather than an attempt to make a unit out of two hours' work would probably be a step toward giving greater prominence to the laboratory work.

The lecture demonstration is used quite extensively and successfully, but formal lectures on chemistry are quite generally tabooed. Many teachers provide individual instruction outside of regular school hours for the weak students.

There seems to be a recognized need for the library in connection with work in chemistry. The value to the student of getting the viewpoint of more than one author is recognized, but the greater value probably lies in gathering from treatments of subjects from the commercial world and from the world of nature a knowledge of the wide application of chemical material. The use of the library in connection with the industries, industrial trips, agriculture, domestic science, and special points in the laboratory are some of the possibilities. One teacher appends a list of references to each laboratory exercise. This, no doubt, is a good practice.

Answers to the question about the method of presenting the subject of chlorin are typical of the wide diversity of opinion among teachers concerning the proper method of presenting the subject of chemistry.

We find a wide difference of opinion concerning the relative ability of the two sexes as measured by the chemistry course. A good majority are of the opinion that there is no difference. Quite a number think there is a difference in interest rather than ability and that some effort should be made to adapt the course to the individual interests of the boys and girls. The large number who report that girls are more painstaking, but boys have better knack for laboratory work would seem to indicate that there is considerable basis for this opinion. It is interesting to note, however, that lady teachers either report no difference or that girls are superior and that men teachers report no difference or that boys are superior. I am inclined to believe that it is only because a greater number of the replies came from men that the conclusion from the report is in favor of the male sex.

The enthusiasm which chemistry teachers have for their work is indicated by the fact that a large number of teachers devote time outside of the regular course to a study of problems which appeal to the student's special interest.

Organic chemistry seems to be considered quite an important factor in the high school course and many are of the opinion that much of the emphasis placed on the chemistry of metals by textbook writers might well be devoted to organic chemistry. The replies indicate that more, rather than less, emphasis should be placed on the study of the atomic and molecular theory, and the periodic law.

Teachers agree that the applications of chemistry should receive considerable attention but that a knowledge of the theory or principles involved should precede the application. Most teachers, however, are of the opinion that the application should be presented as a part of the regular chemistry course. Opinions concerning the practical and cultural value of chemistry are about as well divided as they could be. Answers to the question of values derived from the laboratory course were too varied for tabulation but reading through the replies would seem to indicate one thing pretty definitely. The following statements gathered from the replies are typical of what chemistry teachers say they are trying to develop and accomplish in the laboratory—skill in manipulation, systematic inquiry, initiative skill in observation, exactness, neatness, orderliness, power of analysis, scientific attitude, etc. Knowledge of chemistry and application of such knowledge are not mentioned except in a very few cases. In fact, of about eight hundred things which were listed in all the replies

(many of which are repetitions), which the laboratory work should teach, only about ten were in effect statements that the laboratory should teach chemical knowledge or the application of chemical knowledge. The conclusion to be derived from this is a negative rather than a positive one, and that is the teachers are not trying to make chemistry vocational. Just what they are trying to make out of the course is also a puzzling question. A psychological study of, first, the values of the attributes listed above, and, second, of the possibility of their cultivation by a course in chemistry, would be valuable before we say they are the main purposes for which the course exists. But granted that they are valuable and that they may be cultivated in the laboratory, are they not but the means to a more valuable end, viz., the acquirement of chemical knowledge and the application of such knowledge to everyday affairs of life?

A few chemistry teachers are not in favor of a general science course but most of them are and are of the opinion that chemical material should make up part of the course.

Replies to the question on grading of students make a basis for further study for those interested in grading as a science. Many of the replies gave figures which were based on actual averages extending over periods of one, two, or more terms. Some stated that they tried to get all they could out of their students and then have no failures. Others were rather proud of a high per cent of failures. Here again some one is certainly wrong. Which one is it?

Replies to some of the questions were not tabulated because in some cases the idea expressed by the question omitted is embodied in some other question and in a few cases the replies were too varied to permit of condensed tabulation.

In spite of the somewhat indefiniteness of the aim, this report shows that in general the work done in chemistry in the high schools is quite satisfactory. Some questions that I want to leave fresh in your mind are: How shall we handle laboratory notes? Is patronage of chemistry falling off? How shall we take up a new subject? What material shall make up the course? What constitutes good laboratory method? How can we best use the library in connection with our work? Is there a difference in chemical ability between boys and girls? And, finally, what is the value to the boys and girls of the high school chemistry course?

GENERAL SCIENCE IN THE FIRST YEAR.[1]

BY JOHN C. HESSLER,
Millikin University

The general science question is like the traditional ghost in that it will not down. For two successive years it has been the subject of earnest discussion in the meetings of this Association and in the High School Conference of the University of Illinois, to say nothing of the years it has been before science teachers in other parts of the country. Then, a week ago, both junior high schools and general science were endorsed at the Illinois High School Conference; this action and similar action taken elsewhere make the subject of general science of weighty interest to all high school science teachers, especially to teachers of physiography. If other data regarding this interest were wanting, they were supplied in abundance by the report, presented at a previous session by Mr. C. E. Peet, on the "Present Status of Physiography." If Mr. Peet will permit, I would like to feel that I am really continuing his report. Especially do I hope that what I have to say will arouse those present so that they will discuss the subject of "General Science *versus* Physiography," to the fullest possible extent, with the result that we may have some really constructive suggestions regarding the science of the first year.

By the "science of the first year," I mean the science of the first of the four years of the ordinary high school, or the ninth school year of the average child. The view taken by a rapidly increasing number of educators that technical physiography is not suited to the needs of first-year high school students applies in equal degree to technical biology, botany, physics, or chemistry. If any one of these subjects is used as a first-year course, it must lose its special character and become to a great extent a course in general science. The reason is obvious. Each of these sciences leads the student off into special fields of knowledge; it requires certain antecedent knowledge; it also demands some maturity and a grasp of technical distinctions that is beyond the ordinary child of twelve or fourteen, unprepared as he is for these distinctions. But the child of twelve or fourteen is easily interested in natural phenomena; he is likewise interested in the world of inventions and contrivances by which he is surrounded: he uses the products of civilization whether we will or not. Why

[1]Read before the Earth Science Section of the Central Association of Science and Mathematics Teachers, Harrison High School, Chicago, Nov. 27, 1915.

may we not take advantage of this general interest of the student to enlarge his interest in the world of real science?

But while the argument of the pupil's interest is a strong one, the advocate of general science has no need of depending upon it alone. Common sense teaches us that first things should come first. The fundamental, world phenomena need to be named and studied by themselves before they are applied in the special sciences. Especially should they be studied as something more than mere incidents of the special phenomena of which they are the foundations. The object of the weaving process is to produce the fabric, but the warp and the woof must each start as single, untangled threads. For the same reason, simple phenomena due to gravity, capillarity, solution, oxidation and the like need to be considered *separately* before they are studied in the complex phenomena of the natural world. If it be at all true that "science is only common sense applied to daily life," then science and the scientific method demand that the elementary phenomena should first be considered from a simple, experimental point of view; a knowledge of them should *never* be taken for granted by teachers of the special sciences, certainly not in the case of young, untrained students of twelve or fourteen years.

The preceding paragraphs give some of the reasons why physiography makes so unsatisfactory an introduction to a science course. Its phenomena, as we all know, are not simple, but complex. Consider, for example, the case of erosion. The study of this topic requires an appreciation of such phenomena as those of gravity, solution, oxidation, friction, expansion and contraction of bodies as a result of temperature changes, the action of acids and bases, the expansion of water in freezing, and so on. All of these phenomena can be taught in simple fashion in a general science course. By experiment, demonstration and recitation, the pupil can gain a fair conception of them separately; he will almost never do so when they are woven together in a complex phenomenon like erosion. Moreover, if the pupil learns about each of them as if it were a mere incident to erosion, he will rarely get the idea that they are general and fundamental. But if he studies these phenomena first in separate and simple form, he can then focus his knowledge of them upon complex phenomena like erosion and also upon many other complex phenomena of which they form a part. It is thus apparent that a coures in physiography needs, as its foundation, a knowledge of these elementary phenomena; it needs this foundation quite as much as any of

the sciences do. Certainly, physiography should *succeed* general science, not serve as its basis. Physiography is in fact a most excellent study for the unifying of science work; because of this the high schools of New York City place physiography in the last year and make it a required subject.

Why should not botany and zoology be used as the basis of the first-year science work? The answer has already been given. The botany and zoology so taught will lack the character they deserve. Teachers of these subjects find themselves hampered, even now, in the giving of adequate botany and zoology courses because the time allowed is too short and because the pupils taking the courses have had no preparatory work in inorganic science. The teacher of the biological sciences who would succeed at all supplies the lack by giving time to the study of introductory science, but he does so at the expense of the special sciences he is trying to teach. How much more thorough and significant the course in high school botany or zoology would be if the teacher knew that each of his pupils had acquired some knowledge of simple inorganic phenomena before he attacked complicated, organic phenomena! We may take it for granted that botany given as a first-year science course will be either very inadequate botany or very limited general science. If the course stresses the special topics of botany, the study of inorganic phenomena will become incidental, dwarfed, and of little use for subsequent science work. Such a course will fail to give a satisfying knowledge of either botany or of inorganic phenomena. Here again first things should come first: the study of botany should follow, not precede, or be made the basis of, the study of general science.

Further illustrations are not needed to show that the facts of elementary inorganic science should be made the basis for the study of botany, zoology and the other organic sciences. Why should we not give physics and chemistry, then, as the sciences of the first year? Because to do so would require, as was stated before, an entire abandonment of them as special sciences in the high school. All pupils will not study them as special sciences, but all should have the opportunity; no other studies can take their place for information or for discipline. While physics and chemistry as such cannot be given successfully in the first year of the high school, many of the simple principles and phenomena of which they treat can be taught in a first-year general science course, the course must not, however, include the technical mathematics and theory of physics and chemistry, since these are en-

tirely out of place in a course for the students of the first year.

The argument for adequate first-year general science is strong enough when we consider the important benefits that this study would bring to the botany, zoology and physiography of the later years of the high school course; the argument for it is still more compelling when we consider its relationship to the courses in agriculture and domestic science and to the domestic and mechanic arts. In most high schools the student of agriculture, for example, gets no physics or chemistry until the later years of the course, whereas he needs an elementary knowledge of physical and chemical phenomena in his first year, before he advances to the technique of his agricultural course. What is true of agriculture is equally true of domestic science, domestic art, mechanic arts, and similar applied work. It is well enough for the school to arrange a correlation of physics and chemistry with the more advanced work of the applied sciences in the third and fourth high school years, but the study of fundamental physical and chemical phenomena is needed most at the *beginning* of such courses; the omission of this preparatory study has in the past caused great loss of effort, and, again and again, a practical failure in results. This statement is borne out by the experience of a host of teachers of the applied sciences.

Until now we have been considering the reasons why the special sciences do not make satisfactory courses for the first year of the high school and why general science is needed. Let us now turn to the answer to the question: "What shall we teach in the course of first-year general science?" First of all, I realize that many different answers have been given to this question. From what I have already said, you will guess that I believe thoroughly, as the result of years of experience as a teacher of science, that the course in general science should begin with the study of simple, inorganic phenomena. The ideas of matter, force and energy should be wrought out of the study of such topics as gravity, weight, inertia, centrifugal action, cohesion, capillary action, buoyancy, density, and the like. Then should come the study of air (including the study of air pressure and of pumps), fire and oxidation, heat, water, elements and compounds, carbon and carbon dioxid, magnets and electricity, light, sound, simple machines, acids and alkalies. These are some of the general topics of which I believe the earlier part of the general science course should consist. As was suggested before, we are not interested, in this course in general science, in chemical

formulas and equations, nor in physical laws, algebraically stated, but we are tremendously interested in phenomena, in simple experimentation on the part of pupil and teacher, and in the arousing of clear thinking regarding the world of nature. Upon the basis of physical and chemical facts our general science course should now build a study of the applications of these facts. We should study the home and the benefits it has derived from scientific discovery and invention; the weather, which is essentially the physics of air and water on a large scale; then rocks, soil, and elementary notions of agriculture. From the study of the soil we proceed to plants, which grow in the soil, and to animals, which feed upon the plants. Thus the course brings us to man. We study man through his body (physiology) and through sanitation, or man's relation to his surroundings and to his fellow men. We thus use the study of man not only to teach the pupil the structure of his own body, but also as the means of teaching social consciousness and a sense of modern community life.

Has such a course any purpose? Any unity? Physics can take us from matter to electrons; chemistry carries us from oxidation to radioactivity; botany considers life forms from the protococcus to the daisy; zoology proceeds from the ameba to man; when you want to employ a science that will take you from matter to man, you must seek general science. In criticizing what they imagine to be a lack of unity in general science, may it not be that some of our friends are making the mistake they would make, if, in an art museum, they were to use the same method of examining an impressionistic oil canvas that they employ in viewing a delicate miniature? It is just possible that if they were to stand back far enough so that their angle of vision could include the whole canvas, and so that they could see its parts in proper perspective, they would find that it resolved itself into a thing of harmony and unity.

LABORATORY AND RECITATION.[1]

By Hallie Jennings,

Shortridge High School, Indianapolis, Ind.

The problems of the laboratory in physiography have been worked upon for so long a time that for the most part they have been solved. Many suggestive manuals of fairly usable exercises

[1]Read before the Earth Science Section of the Central Association of Science and Mathematics Teachers, Harrison High School, Chicago, Nov. 26, 1915.

have been written, so that a large body of material is available for laboratory work—yet there may be some benefit in looking again at the more or less familiar points of the subject.

Former Commissioner of Education W. T. Harris has said: "Geography in the schools when well taught does more than any other subject to make the child at home in his environment; to augment his experience and apperception, to arouse in him a thirst for knowledge. This the laboratory can do more effectively and with greater economy of time even than the recitation. And as the old-fashioned sort of recitation gives way more and more to one of supervised study, the laboratory comes to serve an increasingly larger place. By laboratory in this case is meant not only the formal classroom exercises but work in the field as well. All must grant that the field is the real laboratory and only when this fails or is inaccessible do we come to the classroom and sand table as a last resort.

To work with the greatest economy to the class, several points must be considered carefully. First, what is the purpose to be gained in the laboratory. Second, What subjects are best dealt with in the laboratory?

As to the purpose of the laboratory in high cshool, it is primarily to give the pupil a certain amount of definite experience with substances, the laws and facts governing them, which experience may serve to explain and fix firmly the few essential points needed as a foundation. Then, too, the laboratory when carried into the field should give the child a knowledge of his environment which will enable him to compare the advantages of his own region with those of another and help him to make the best use of his own.

What subjects are best presented in the laboratory and the manner of presenting them must be largely a matter of the needs of the individual class. Yet some lend themselves to such demonstration better than others. Unless accompanied by copious illustration, such subjects as rocks, soils, work of rivers, topographic maps, and many others, mean very little. Especially does the class in first-year science in a city need such added demonstration of the facts of the text, in order to make those facts concrete and usable.

One plan which has been followed may be of interest as giving familiarity with rocks and minerals, their kinds, composition, uses, etc. The class began by identifying, in terms of cleavage, hardness, luster and streak, some fifteen or twenty common min-

erals, this being done as a preparation for understanding composition and physical properties of common rocks. After learning to recognize feldspar, quartz, mica, calcite—and knowing something of their chemical composition—the pupils were able to understand the composition, chemical and physical, of rocks as they never could have done before. Granite with its feldspar, quartz and mica, weathering into clays and sands, has a concrete and very real meaning to them after such a preparation. Shale, limestone and sandstone have distinctly different composition and different uses. Then the pupils were ready to work independently in applying their knowledge to the rocks of their own creeks and fields and of the buildings about them, in making a collection of typical rocks of their own region, and also in finding what kinds of rock are used in the buildings.

After collecting the rocks, they mounted and labeled them and brought them into class. I know of nothing better than an exercise of this sort to give a child knowledge of his own environment and an enjoyment in it. The collecting and labeling was probably the most profitable part of the whole plan.

Much the same method may be used with soils—only here the added points to be fixed are porosity and capillarity. To most of the children these words convey little meaning until they see water standing on top of clay, but creeping rapidly up into it; slipping quickly into sand, but crawling slowly up into it. After a demonstration of this sort, such topics as conditions for artesian wells and methods of dry-farming explain themselves with no difficulty.

The use of topographic maps, their interpretation, the making of cross- and long-sections are of tremendous value in giving a knowledge of different regions. Especially if this can be done with maps of the home region, does it give an excellent basis for comparison with others.

Then the study of weather maps, the making of forecasts, keeping a weather record for skill in use of the different instruments, the making of graphs and maps, enlighten many obscure topics.

But better even than this sort of laboratory work is that which is carried on in the field, for nowhere can the work of a stream be better studied than along the stream itself. Here also can be found rocks, soils, stratification, glacial drift, all types of relief forms, different slopes in terms of which the pupil can better interpret topographic maps. Nowhere else can drainage and possibilities of flood prevention be better studied—and to citizens

of the Ohio River states, this is a problem which requires a broad understanding of real conditions in order that it be intelligently solved. This by no means exhausts the list of subjects which may be profitably treated in the laboratory, but merely suggests some of those best suited.

In high school, physiography is essentially a basal science, given in the first and second years; hence, in general, it can presume practically no previous scientific knowledge on the part of the pupils, but it must give a good foundation for all future science by fixing well a few fundamental laws and facts. This must be done by presenting the subjects in class and laboratory, working them out again with the class in the field, and, finally, by setting some task which will bring the pupil to work them through, alone at home.

In conclusion, every first-year physiography class is essentially a class in general science, so closely and constantly does it touch physics, chemistry, the biological sciences, etc., and the laboratory exercises must meet each of these needs. Hence there arises a great difficulty in maintaining a steady purpose in all this work, thus avoiding great waste of time, by eliminating unrelated or useless exercises, which may lead too far afield in some one of the related sciences.

As a simple matter of economy to the child, one thing well taught gives a much better foundation for independent and efficient work, than a smattering of all things with no one thing fixed.

CURRENT EDUCATIONAL MOVEMENTS AND GENERAL MATHEMATICS.[1]

By H. E. Cobb,

Lewis Institute, Chicago.

Abstract of Discussion.

The history of education in Europe has been divided into three great epochs. During the first epoch the individual was educated for the state, during the middle ages for the church, and in recent times the purpose of education is to develop the individual himself. Milton stated his belief as follows, "I call, therefore, a complete and generous education, that which fits a man to perform justly, skillfully, and magnanimously, all the offices, both public and private, of peace and war." No doubt we today accept this as a satisfactory definition. But our efforts are not directed solely to the task of preparing a few great men and women for preëminent leadership in public and private enterprises. During the last fifteen years the number of students in secondary schools has increased in a marvelous degree; and it is our duty and privilege to provide work which in content and method shall develop the individual, and prepare him for useful and effective service for others and for himself.

In the present discussion we are to confine our attention to only a very small part of this great question. Indeed, it is only a part of a part of this problem. We are not to consider what office mathematics has in developing the power of deductive reasoning, of critical analysis, of exact definition, of clear statement. Nor are we to attempt to prove that mathematics is the most important subject in secondary schools by quoting the historical statements of John Stuart Mill, Comte, Sir William Hamilton, Lord Bacon, Locke, and other great philosophers. This method of proof has seemed to me to be quite beside the mark, since the mathematics that they talk about is not the mathematics taught in the schools.

We are to take mathematics as it is taught in the schools at the present time, and consider the possibility of doing our work to the greater advantage of the students, by combining the different branches of mathematics into a single coherent course.

But at this suggestion there is still a somewhat general feeling that it cannot be done, and in some quarters there is a persistent and preëmptory denial of the possibility of making such a com-

[1]Read before the Mathematics Section of the Central Association of Science and Mathematics Teachers, Harrison High School, Chicago, Nov. 26, 1915.

bination. The claim is made that algebra and geometry are essentially distinct subjects, and therefore cannot be united. The Greeks had no experimental science, and the later Greek mathematicians even drew a sharp distinction between the science of numbers and the art of calculation. Euclid had nothing whatever to do with calculation, and in this he was followed by most of his successors. It is no wonder, then, that the system of geometry presented by Euclid is a logical, self-consistent whole, sufficient unto itself and completely isolated from all other subjects. If Euclid scorned arithmetic, that is no reason why a boy studying geometry today, should proceed as if he knew no arithmetic. Professor Perry's words with reference to the separation of geometry and mensuration may be applied to the whole question. He says, "Surely, it is an abominable thing to maintain the present artificial distinction between mensuration and geometry, and to scorn arithmetic, which we know, because Euclid, being ignorant, did not use it." I have tried at times to imagine the beautiful system of mathematics we would have now, if Euclid, Appolonius, and Archimedes could have collaborated on a textbook in general mathematics.

To my mind this matter may be summed up as follows: Algebra and geometry are sciences—systematized knowledge—organized and perfected as distinct sciences by reason of causes and accessory conditions seemingly fortuitous, taught in the schools chiefly as a discipline or an instrument of knowledge, and destined because of these circumstances, to yield an inadequate recompense for the efforts of teachers and pupils. It is proposed to unite these and possibly other allied subjects, to make this transformed subject more of an art than a science, and to make this the work of one or two or any number of generations of teachers, with the full confidence of perfecting a branch of study of greater service to boys and girls.

The first meeting of this section was held on April 10, 1903, at Armour Institute where the Association was organized. Dr. Myers was the Chairman, and the topic of the meeting was the Perry Movement. Professor Alderson of Armour Institute gave an address on "What is the Perry Movement?" and read a letter written by Professor Perry to the section at the request of Professor Alderson. One paper pointed out the need of a Perry Movement in the United States, and other papers discussed what might be done in the way of introducing physical and other problems into mathematics, and methods of doing laboratory work in the mathematics classroom. The point to be emphasized, if I am

not mistaken, is that our present Chairman was the only person present at that meeting who could tell of some real work actually done in the classroom to combine algebra and geometry. She had already established a course in which each subject in algebra was introduced through examples taken from physics and geometry, and the explanation of the meaning given through these examples. While she has continued this pioneer work, others have caught a vision of better things, and now in a number of schools methods of connecting the different branches of mathematics are being tried out. In no place has this work been done better than in the University High School. Dr. Myers' *First-Year Mathematics* and *Second-Year Mathematics,* and the recently published *First-Year Mathematics* by Mr. Breslich bear evidence of patient and careful experimentation and judicious selection of material from algebra and geometry, woven into a homogeneous and harmonious subject that is real mathematics.

The discussions of unified mathematics in our section meetings and the experiments that have been made in different schools in our territory have had a marked influence on the character of textbooks in arithmetic, algebra and geometry during the last twelve years. It is certainly a matter of interest that there have been published during this time, more than sixty textbooks written by members of this section. This does not include a number of mathematics books written by members of the Association who do not attend the annual meetings and who take no active part in the section meetings. Most of these books *do not* claim to be conservatively safe and sane in the adoption of new notions.

Since we are teaching boys and girls rather than algebra and geometry, and since there is no real necessity for teaching these branches of mathematics as sciences, it seems to me that the path of future progress is clearly indicated. In most schools at the present time, it is not possible to replace the courses in algebra and geometry by a course in general mathematics. But this does not preclude the possibility of doing some good work in uniting the subjects. At the Lewis Institute we have been working along this line for several years; a description of our plans and methods is given in the 1913 PROCEEDINGS of the Association.

In this section we have a large body of earnest and capable teachers and it seems to me that the best possible means for any teacher to obtain promotion to a higher place of responsibility is to lay plans for a thorough study of this problem, and to decide what can be done in his own classes. Then go ahead vigorously but carefully with some real live experimentation. This work well done will benefit not only the teacher, but the pupils as well.

ALGEBRA FROM THE UTILITARIAN STANDPOINT.[1]

By Dr. A. R. Crathorne,

University of Illinois.

Without detracting anything from the value of algebra in its disciplinary, cultural, or ethical aspect, it is the purpose of this paper to examine algebra from the utilitarian or practical standpoint. More particularly, it is the object of the paper to investigate the part that different topics of algebra play in the applications. I have classified the utilities of algebra into four subdivisions. They are not mutually exclusive nor equally important. Perhaps I should not use the word "equally" in this connection for I confess that I cannot clearly define the terms "equal to," "greater than," "less than," as they are used here.

We have, first, the utility of a direct kind in the vocations. Let us call it vocational utility. This includes among other things the use of algebra in the trades and in reading trade journals. A not unimportant utility included here is the use of algebra in vocational selection where in my opinion it is just as useful as manual training. Vocational utility particularly touches the boy who does not intend to finish his high school course.

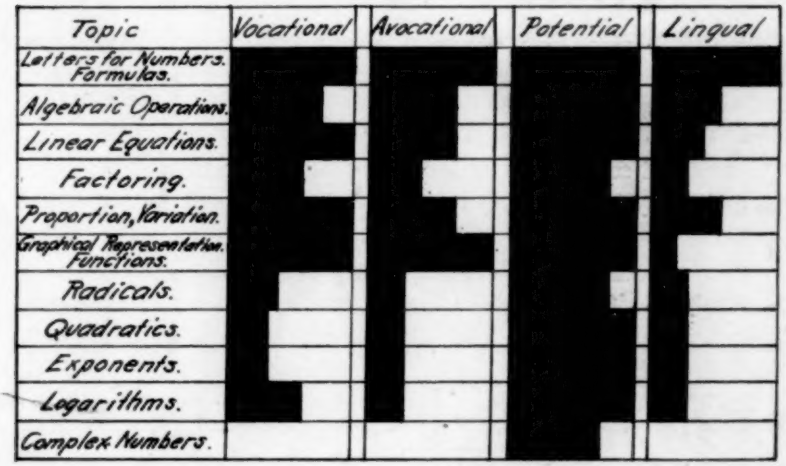
Then we have the utility of a direct kind in the leisure of life. This includes the use of algebra to the ordinary, educated man in his daily life and reading. This touches the cultural side rather closely and there are reasons for not including it among the utilities of algebra. Let us call it avocational utility.

Third, we have the utility of an indirect kind in that algebra furnishes a necessary foundation for a profession. This is the utility which appeals to the student who expects to enter one of the professions to which we may apply the word "exact," such as engineering, chemistry, accountancy and actuarial science. This we shall call potential utility.

Probably the most practical subject taught in our schools is English. Few subjects are better adapted to giving exercises in clear-cut English than are some parts of algebra. The ideas to be expressed are definite, a sufficient vocabulary is given the student and mistakes are easily pointed out. At the same time the practice in English helps the student with the difficulties of algebra in a way which merits more appreciation. Let us for want of a better term call this lingual utility.

[1] Read before the November, 1915, Conference of High Schools with the University of Illinois.

I shall then take up different topics in algebra and discuss them in the light of these four utilities. To aid the eye I shall use a sort of graphical representation. In the figure the amount of shading in any rectangle gives my opinion of the importance of the corresponding topic in the corresponding utility. I hope no one will be very inquisitive as to the exact amount of shading in any particular rectangle. A rectangle fully shaded means this topic is very important in this utility.



Use of Letters for Numbers, Including Evaluation of Formulas.

This, the very elementary and fundamental part of algebra, is of course necessary for all the algebra which follows. It is useful in nearly all trades. A man can read few trade journals without meeting algebraic formulas. For the ambitious boy who can profit by correspondence and night school work, it is almost indispensable. Anyone who has had experience with correspondence work knows that in most cases "well begun" is not "half done" by any means. One of the dropping-off places is the first touch of mathematics.

This subject is of direct use to the ordinary, educated man in his daily life. Due to the automobile, aeroplane, and the war, our general reading of the past few years has increased in technical phraseology. One of our most popular journals for boys and young men is the *Scientific American*. At our co-operative store I recently counted seven magazines devoted to the popular side of mechanics. Attempts at description without symbols are sometimes ludicrous. In our library I recently picked up an interest-

ing book describing in non-technical language the theory of many modern mechanical inventions. In the chapter on the steam engine, the author uses three pages to explain the meaning of maximum efficiency, and methods of increasing it. He then naïvely remarks that, if he could be so bold as to use algebraic symbols, all he had said could be summed up in the statement

$$\text{Max. eff.} = \frac{a-b}{a},$$

where a is the temperature of the steam entering the engine and b the temperature of the condenser. Since the numerator of this fraction is less than the denominator, the efficiency will be increased by increasing a, the temperature of the steam entering the turbine.

In an indirect way, of course, this subject is absolutely necessary for any student who is going on with engineering or chemistry.

The translation of formulas into English and explanations in English, without the use of any symbols whatever, gives understanding in the algebra and help in expression. The translation into English of a few simple and familiar statements such as

$$v = \tfrac{1}{3}\pi r^2 h, \quad F = \frac{9}{5}C + 32, \quad A = \sqrt{s(s-a)(s-b)(s-c)},$$

impresses one both with the utility of algebraic symbols, and with the difficulty of making certain exact statements in English without the use of any algebraic symbols.

We have in the University of Illinois graduate students in agriculture who find themselves under the necessity of delaying the work in which they are directly interested in order to study the freshman algebra that they find essential to the study of their problems. For them, algebra has been found to possess a utility of which they were not at all aware in their undergraduate days.

Moreover, as any science develops, it becomes more quantitatively exact, and this in turn increases the use of algebraic formulas. Hence, the utility of algebra as a medium of expression is on the increase as surely as we are gaining more exact scientific knowledge.

Algebraic Operations.

This subject is, of course, the very heart of algebra. It is here that the spectacular errors are made, which are thrown back at mathematics teachers by teachers of subjects requiring algebra as a prerequisite. We have perhaps all heard with chagrin how

one of our former students has said $(a+b)^2=a^2+b^2$, $\frac{1}{a+b} = \frac{1}{a}+\frac{1}{b}$, or has cancelled the a's in $\frac{a+b}{a+c}$ As regards the utilities, it is of use in all of them, though perhaps the first, second, and fourth rectangles are not so heavily shaded as the corresponding rectangles in the first row.

We often see it stated that the reduction of complicated algebraic expressions is a profitless task that has no justification. I do not subscribe to this view. I have had more or less to do with many problems that have arisen in actual technical practice and I find that in a great many the chief difficulty has been in the very complexity of the expression derived. Students are too prone to throw up their hands at an "armful of algebraic symbols" as one of my students expressed it. Those who go on with mathematics into the calculus often find the algebraic reduction the most difficult part of the subject.

Linear Equations and Systems of Linear Equations.

Algebra is often said to center about the equation. Discussions as to the order of topics in a course in algebra usually end in a draw when the time of introduction of the equation is reached. It is a notable point in the economics of our universe that many pairs of variables are united in a linear relation. Many of these are within the experience of the fourteen-year-old and it is here that the pupil first sees algebra applied in a way which he understands. Solutions of useful problems involving motion, simple interest, mixtures, and the lever involve linear equations. These problems are in many cases of such a character that a solution without algebra would be effected with much difficulty, if at all.

On the vocational side, the linear equation is very important and is necessary to the ambitious man who often solves them though he may not know the meaning of the word equation. At present publishers are turning out many books on practical mathematics for working men. I have received four such books since the beginning of this semester. In one of them, a book for machinists, I find scores of equations though the word equation is not used in any part of the book. For example: To find the pitch when outside diameter and number of teeth of a gear are given, we find

$$\text{Pitch}\times\text{outside diameter}=\text{number of teeth}+2.$$

The solution is given in English and then, to summarize, the pitch is represented by x and the algebraic solution given.

On the avocational side, the linear equation is useful to anyone interested in automobiles, aeroplanes, or popular mechanics. It is useful in all sorts of simple interest problems and it even has a humorous side for that great body of people interested in the age of Ann or the more recent problem of the two motorcyclists, However, I think its utility is less marked here than on the vocational side.

It is unnecessary to discuss the place of the equation in the third column. In the fourth, the exercises are mostly translations from English into algebra, which from the language side is not as good an exercise as the translation from algebra into English.

Factoring.

Factoring occupies an important position in our courses in algebra at present. From the utilitarian standpoint, with the exception of the third column, it is not so important as some other subjects. The principal office of factoring is as an auxiliary to the solution of equations and the reduction of algebraic expressions. It also serves to fix in mind certain important elementary forms such as the difference of two squares, the square of a sum and so on. In this latter connection we find much good in English translation. However, in my mind, we could advantageously trade some of our factoring for more drill in the theory of exponents.

Proportion and Variation.

The terminology of this part of algebra perhaps permeates our ordinary reading and speaking more than any other part, whether we use the older term, rule of three, or the more modern graphical phrase, straight-line relation, for direct variation. Much of the difficulty lies in the technical word "vary," which differs from our ordinary use of the word. A few examples given in English and algebraic language will show the wide application of this topic to all the utilities.

The velocity of a falling body starting from rest varies with the time,

$$v = gt.$$

The pressure of a gas varies inversely as the volume,

$$p = \frac{k}{v}.$$

Price varies as the number of articles purchased,

$$p = kn.$$

The crushing load of a solid square oak pillar varies directly as the fourth power of its thickness, and inversely as the square of its length,

$$l = \frac{kt^4}{l^2}.$$

The statement, acceleration is proportional to force, is sufficient to show the potential utility of this topic.

I have seen a night school course for working men which had a list of over one hundred applications of variation to problems in weight, time, shearing stress, generation of hydrogen, penetration of armor, strength of current, vibration of strings, friction, flow of gas, and so on. A good example of the use of proportion is the reading of a working drawing. A member of our chemistry department told me a few days ago, that for students in chemistry, the theory of proportion was the most used part of the algebra.

The rectangle in the second column is not shaded so much as the others, not that the educated man does not use proportion, but it is harder to find specific examples of its use, which do not belong to the other columns.

GRAPHICAL REPRESENTATION; FUNCTION.

For a long time the equation ruled algebra. Our attention was focused upon certain numbers which we called unknowns, and which when substituted in certain given expressions gave given numerical values. Of late years, however, our view has been broadened to take in a whole set of values of the given expression. We discuss variables as well as unknowns. We study the whole range of values of the expression and not just one or two which satisfy certain very limiting conditions. Graphically speaking, we have changed from an examination of the points where one curve crosses another curve to an examination of the curves.

This is one of the notable changes brought about in our algebra by the pressure from outside. The world is full of variables which depend on other variables, presenting to us the problem of finding out and exhibiting the manner of dependence. The office of the graphical methods of algebra is to exhibit this dependence to the eye, and not, as many textbooks would imply, merely to aid in the solution of equations.

This graphical representation of tabulated values, even when no formula is given, has become so generally useful that we find in

non-mathematical books illustrations of the use of the graph in exhibiting historical statistics, weather reports, laws of mortality, changes in price, and so on. I know one grocery man who keeps on his office wall a chart showing his daily sales for several consecutive years. I knew a boy who followed for a season the rise and fall of the percentages of the major league teams by graphs. We may then fill up the avocational rectangle. For the working man this topic is partly absorbed by the topic, evaluation of formulas. The graph, however, is creeping into his work. In a recent book for working men in shop mechanics, a full page is devoted to an explanation of the stretch of copper wire for different loads. The author, no doubt realizing the vagueness of his explanation, then clearly sums up everything by a graph with three lines of English under it. I know a tinsmith who makes milk cans with the usual conical top and spherical bottom. He furnishes measuring sticks to tell the amount of milk in a can. He graduates these sticks by means of a graph constructed from experimental data.

On the potential side, graphical representation is used as the first step in the treatment of the function in its more analytical aspect. This part of the course in algebra is applicable and necessary in any work the student may do later in mathematics or the exact sciences. I sometimes think that the main difficulty in this part of the algebra lies in the technical word, "function," which to the fourteen-year-old is not very suggestive of the idea of dependence.

Radicals.

Some writers have advocated the exclusion of radical signs from all mathematics. Perhaps, if we could begin anew with a revised symbolism, we would reject the radical for the fractional exponent. But, for some time at least, we are to be chained to the radical sign. I notice in comparing some of the articles on mathematics in the ninth and eleventh editions of the *Encyclopedia Britannica* that the fractional exponent has to some extent replaced the older form.

The working man does not use the radical very much in his actual work. He has his carpenter's square for finding diagonals or cut and dried methods of finding roots. In reading trade journals he often meets the radical and here needs to know some of the theory. For example, in chimney construction,

$$e = a - .06\sqrt{a}$$

where e is the effective and a, the actual area. Perhaps we may find food for thought in the answer of one skilled workman to a question as to his use of the radical. "Well, if I knew all about that, I wouldn't be getting days' wages but be drawing a salary."

The avocational rectangle seems to be even harder to fill than the vocational. In amateur mensuration and in reading popular mechanics we find the most use for a knowledge of the radical.

For specific illustrations of the utility of radicals on the potential side, we need only be interested in measurements, whose adjustment requires the Pythagorean proposition, to meet the radical $\sqrt{x^2+y^2}$. We need to be interested only in knowing the velocity of a falling body to meet $\sqrt{2gs}$. The time of vibration of a pendulum is given by $2\pi\sqrt{\frac{l}{g}}$. Again, we need only study a uniform cable suspended from two supports to meet the function $\log(x+\sqrt{a^2+x^2})$, whose derivative is

$$\frac{1+\dfrac{2x}{2\sqrt{a^2+x^2}}}{x+\sqrt{a^2+x^2}}=\frac{1}{\sqrt{a^2+x^2}},$$

a good practical example of the simplification of radicals and of complex fractions so common in the calculus.

The application to English is limited to the translation of the rules for radicals into nonsymbolic language.

Quadratic Equations.

We rarely find a simple problem in life which reduces to the solution of a quadratic equation. The importance of quadratics comes usually in connection with a larger problem, in whose reduction the solution of a quadratic is necessary. Though the larger problem may be extremely practical, yet the solution of the quadratic equation involved may be very abstract. We may be able to give physical meanings to the coefficients, but usually these are not important enough to have received names. For example, in the important problem of an electric circuit which branches off into two parts, we start off with certain letters—e_0, v_0, v_1, v_2, x_0, x_1, x_2, representing volts and ohms. In the problem of finding the current strength at any point of the divided circuit, we have in the course of the work to solve the quadratic equation in a

$$a^2x^2-as^2+r^2=0.$$

where $x^2=x_0x_1+x_0x_2+x_1x_2$,

$$r^2 = r_0r_1 + r_0r_2 + r_1r_2,$$
$$s^2 = r_0(x_1+x_2) + r_1(x_0+x_2) + r_2(x_0+x_1).$$

A rather simple, but interesting problem for the avocational side came my way the other day. A new cheap edition of the *Encyclopedia Britannica* is being made by a photographic process so that thirty-two pages can be printed on a sheet of paper instead of sixteen. A friend telephoned me to know if this edition would stand upright in his sectional bookcase with room at the top for his fingers to get a book out. That this problem struck me so forcibly as an application of the solution of the quadratic was, of course, due to the rarity of such problems. We find in this case then that the third rectangle is well shaded while the others are nearly all white.

Exponents.

Here we have another unassuming, but very important topic. It would be difficult to explain to the business man or to any skilled artisan, how he could use the theory of exponents in his work. Bankers laugh at what they call the mathematician's delusion about interest compounded continuously. But in the theory and practice of long-time finance involved in certain phases of life insurance, the actuary finds this conception of interest more simple and practical than is compound interest with conversion periods of the kind known to the average banker. There are many things in the world of our experience whose rate of change is proportional to the measure of the thing itself (another way of saying that the thing changes as does money placed at continuous compound interest). The pressure of the air as altitude increases, the temperature of a cooling body, the friction of a pulley belt, current strength in certain electrical problems, are a few examples of variables which follow this important law which may be summed up in the formula

$$y = e^{ax}.$$

Our simplest and most practical treatment of life insurance on two joint lives rests on a mortality table given by the formula,

$$y = ks^xgc^x,$$

where x is the age and y is the number living at age x. We thus use a two-story exponent, as some have slightingly called such expressions, in a very practical problem of life insurance.

But these uses are not so important as the abstract use. Like the quadratic equation, the usefulness of the theory of exponents lies hidden in large problems. To many an engineering problem, especially in electrical engineering, the theory of exponents bears

the same relation that the steel girders bear in the finished skyscraper. No one can accuse the physicist, Faraday, of being unduly inclined towards mathematics, yet he said: "There is nothing so prolific in utilities as abstractions."

Logarithms.

Few subjects in mathematics have a greater economic utility than has this topic which is so closely related to the theory of exponents. We can not measure its usefulness in lightening the labor of computation, in the sciences, in the trades, in navigation, both water and air, in surveying, in mining and in all branches of engineering. Imagine the work of computing our nautical almanac without the use of logarithms! Imagine the engineer suddenly deprived of his slide rule! What would the student of steam engineering do with such expressions as

$$t = t_0\left(\frac{p}{p_0}\right)^{\frac{g-1}{g}}, \text{ or } pv^{\frac{17}{16}} = 475?$$

The applications to the computation of compound interest and to the extracting of roots are among the simplest examples of the utilities of logarithms. In a recent work on vocational mathematics, at least one-quarter of the book is devoted to logarithms and the slide rule.

The importance of this subject in the potential and vocational side far outshadows its importance in the other two. In his scientific reading it is convenient for the educated reader to understand what a logarithm is, and to understand the use of a table, but the convenience of Napier's invention does not impress us so much as in the vocational or potential sides. The English rectangle will be rather blank.

Complex Numbers.

This is a difficult topic in algebra. It would be less difficult if it were not associated so much with the word "imaginary". The bright pupil wonders what can be the use of it. He can think of ten feet, minus five degrees, half a bushel, but it takes some explanation on the part of the teacher to couple ten miles northwest with a complex number.

The utility of the complex number is mostly of the potential kind. Besides its utility in measuring velocities, voltages and other things which seem to need two numbers to represent them, it is important in a very different way. Without the complex number, we could not say that every quadratic equation has two roots, nor that any rational integral equation has at least one

root. In general then, we may say that the complex number makes possible many general theorems in mathematics and thus simplifies mathematical reading.

We have then before us a diagram analyzing algebra as to its utilities. Ten men making the same diagram would arrive at ten different results, but I think that they would all be alike in one particular. The third column would be shaded more than the other columns. The real importance of algebra does not lie in the immediate applications which it is possible to bring before a pupil, but in the fact that algebra is a part of the great material world about us, a part which must be investigated and understood by all who do not wish to limit their opportunities when the time comes for making a choice of a profession. Giving the high school pupil a glimpse of this side of algebra is nothing but common sense in teaching whether we are interested in the disciplinary, cultural, or utilitarian side. Let me emphasize this part of the problem of teaching mathematics by a sort of parable.

Something ailed the Average High School Pupil. His appetite was capricious, he showed little interest in his studies, and felt a great disinclination to work. From Monday morning to Friday afternoon he was prey tc all sorts of ailments, headaches, toothaches, coughs. So serious seemed his case that a consultation of doctors was called. There was Dr. High Brow, an old school allopath, the leading physician of the community. Then came Dr. Practical Man, who was younger and the surgeon of the town. The third member of the consultation was Dr. Brown, the family doctor, a physician of no particular school and of small reputation among his colleagues, for he had been known to advise his patients against operations, and at times even to recommend osteopathy. Notwithstanding, he had a large and successful practice. An Average Parent made the fourth member of the consultation.

The Average High School Pupil was produced and carefully examined. It was found that he was suffering from internal strains. Eighty per cent of him never intended to go to college, ten per cent intended to go, and ten per cent did not know whether it would go or not. All the doctors agreed upon the diagnosis and being up-to-date medical men agreed that the suffering caused by the strains was but a symptom of something else. Further examination and questioning of the average parent suddenly brought Dr. Practical Man to his feet with, "I have it. It is his algebra. This modern high school algebra is too strong

for the eighty per cent which causes it to pull away from the other twenty."

"Yes," says Dr. High Brow, "I think it is the algebra, but the case is not as you present it. The algebra should be stiffened, for by developing the ten per cent of collegiate tendency, the remainder will be sure to be strengthened and brought into closer union."

At this point the Average Parent jumped into the discussion with, "What is the good of algebra, anyway? As an Average Parent, I have had three weeks of algebra, and I certainly have never had any use for it."

"Your question is to the point," says Dr. Practical Man. "Remove the cause by operation, and the strains will disappear."

"Rubbish," exclaimed Dr. High Brow, "algebra has always been part of our required work in the high school. If it had not been necessary it would have been thrown out long ago. Hammer it into them until they get it. Ah! If the boys only got it as I did in school!"

"So, you are fond of mathematics?" broke in Dr. Brown.

"Fond of it," roared Dr. High Brow. "Why, I studied medicine because I was pretty sure not to meet any of it there. But you haven't expressed your opinion as to the cause of the strains."

"In a way," answered Dr. Brown, "I think you are both right and both wrong. I have no doubt that the trouble lies in the algebra, but I would rather investigate the algebra a little more than operate or stimulate with strong medicine."

Then turning to the Average Parent, he asked him how long the trouble had lasted.

"Well," said the Parent, "he started out in his work briskly enough. I used to ask him about the good of that algebra, and his answers were very vague and when I'd pin him down he became more and more irritated. Then his uncle came to visit us, and talked a lot about the uselessness of algebra and how he had forgotten all he had ever learned and was proud of it and—well, the boy seemed to lose interest. I can hardly blame him. I can see lots of use in the manual training and the typewriting and in the English. I can see some use of a modern language. I can understand things made of steel or wood. I can see the use of ability to write a good business letter in English or any other living language, but when it comes to such things as complex fractions, exponents, or imaginary numbers, it does seem to me to be too airy and too far-away from anything practical."

"But, my dear Average Parent," said Dr. Brown, "I take it that you consider wireless telegraphy to be practical, but in its development, the theory of exponents bore just as large a share as steel, brass, or glass. Look over Lord Kelvin's laying of the Atlantic cable and after having your ship and your wire and guttapercha, tell me how you would do it without complex fractions. Gather together wire, cloth, gasoline, steel, and wood to make an aeroplane and where would you be if you had no radicals? Look over the plans of the Diesel gas engine and think how long Diesel would have experimented if there had been no such a thing as proportion. We are just now in a stage of advancement in long-distance telephony due to the work of Professor Pupin. Look over his work and estimate if you can the money value of factoring. What might happen to a steel bridge if the designer had said that $\sqrt{a^2+b^2}$ equals $a+b$? Ask the electrical engineer whether he would rather see a rise in the price of copper or a sudden disappearance of the complex number. What insurance investigation would cause such consternation as a discovery that the commutative law no longer held? What artillery officer ——?"

"Oh! If you put it that way," interrupted the Parent, "perhaps the algebra is of some practical value, but how do I know that my boy will ever need it?"

"You don't know," answered the doctor, "you don't know that he will ever use his German, or ever again stand before a turning lathe, but if you do induce him to drop his algebra, you may forever close to him the door of entrance to the profession for which he is particularly fitted."

Dr. High Brow, who had been listening with interest, broke in at this point.

"But, what of the boy who is studying algebra for its own sake? Is nothing worth while that can not be applied to something else? Is there to be no cultural or disciplinary value in his work? Is the boy to think of algebra as leading merely to bread and butter?"

"My dear Dr. High Brow," answered Dr. Brown, "I know a young man who is now one of the brightest mathematicians of his class in a certain university, who became interested in his mathematics by way of the automobile. At least one President of the American Mathematical Society entered mathematics from physics. I have said nothing against the cultural or disciplinary side of algebra. Strong as they are, they will be strengthened rather than weakened by remembering that we are teaching al-

gebra to a fourteen-year-old boy. We must talk to him in a language he understands. We should present the subject in such a way that he knows it is not a purely abstract science, but one that touches the objects of his experience. He should be given a glimpse of its greater applications."

Dr. Practical Man, who had been silent and evidently thinking, here took up the argument.

"Take, for example, a grocer. What use ——?"

"I was waiting to hear from the grocer," said Dr. Brown. "We are not discussing grocers, but the high school freshman. If we knew that all were going to be grocers, or even if we knew which ones were going to be grocers, our case would be different. Our problem is to give to the high school pupil a broad view of what may lie in the future and to give him a course from which he may be better able to judge for himself as to his best line of endeavor."

"It seems to me," said the Average Parent, "that the discussion is becoming pretty general. What about my boy?"

"We are coming to that, my dear Average Parent. We are all agreed that the trouble lies in the algebra. I recommend, instead of dropping the algebra, or stiffening it, that we simply adjust the algebra to fit the boy, that we not only emphasize those parts which have immediate applications within the boy's understanding, but that we give him some hints of still greater utilities. If he seems to dislike algebra ——."

"But, I don't dislike algebra," broke in the Average High School Pupil who has been restlessly listening to the arguments. "I never did, but so many people argued that I disliked it, that I began to think there was something wrong with it."

"Well," says Dr. High Brow, pulling on his gloves, "I have other patients. Seeing I've forced you to say that there is disciplinary and cultural value in algebra, I am willing to compromise. You make out the prescription. I'll sign it."

"I'm not so sure," says Dr. Practical Man. "But you can try out your treatment and report. Meanwhile I'll look up about Lord Kelvin and his cable, Diesel and his gas engine and those other things you mentioned."

The consultation ended, and as he was putting on his coat, the Average Parent in a puzzled way muttered to himself:

"And men go up in flying machines made of wood, wire, complex fractions, gasoline, and exponents."

A MATHEMATICAL ANTI-GAMBLING ARGUMENT.

By Harry M. Roeser.
Washington, D. C.

Suppose Jones has m dollars and Smith has n dollars. It is proposed to show that if Jones repeatedly bets Smith a dollar against a dollar in a fair bet, one of them eventually *must* go broke.

The particular scheme or schemes of putting the money at risk, whether it be cards, dice, or tossing coins, is a mere detail, and, furthermore, the play may be continuous or periodic. At some time after the play begins, one of them, say Jones, will have x dollars and the other will have $m+n-x$ dollars.

At this period let Jones' chance of winning all the money be p_x. Also let p_{x+1} and p_{x-1} be his respective chances of winning all the money when he has $x+1$ and $x-1$ dollars. Now since at the next bet he will either have $x+1$ or $x-1$ dollars and, since the probability that each of these quantities represents his financial condition is $\frac{1}{2}$, it follows that,

$$p_x = \tfrac{1}{2}p_{x+1} + \tfrac{1}{2}p_{x-1}.$$

Those familiar with the fundamentals of the theory of probability will at once recognize this equation as stating the facts. For those who have a somewhat hazy recollection of the last few pages of their algebra text, it is deemed desirable to indicate without unnecessary detail just why the above relation is true. The demonstrations of the following propositions may be found in any pretentious work on algebra.

1. The probability of the simultaneous occurrence of several events is the product of the probabilities of the separate occurrence of each.

2. The probability of the occurrence of any one of several events of which only one can happen is the sum of the probabilities of the separate occurrence of each.

Consider now these events:

(i) Jones may have $x+1$ dollars at the next bet—probability, $\frac{1}{2}$.

(ii) He may win all the money after his wealth is $x+1$ dollars—probability, p_{x+1}.

(iii) He may have $x-1$ dollars after the next bet—probability, $\frac{1}{2}$.

(iv) He may win all the money after his wealth is $x-1$ dollars—probability, p_{x-1}.

(i) and (ii) are two events which may occur together and according to Proposition 1, the probability that they do occur together is $\frac{1}{2}p_{x+1}$. Similarly, the probability that (iii) and (iv) occur together is $\frac{1}{2}p_{x-1}$. Now either (i) and (ii), or (iii) and (iv), may happen together, but the pairs of events are mutually exclusive, i. e., if (i) and (ii) happen, (iii) and (iv) cannot, and conversely. The present chance that one pair will happen is p_x and, therefore, according to Proposition 2, it is,

$$p_x = \tfrac{1}{2}p_{x+1} + \tfrac{1}{2}p_{x-1},$$

and this equation is true for all values of x.

Since $p_x = \dfrac{p_{x+1}+p_{x-1}}{2}$, p_x is the arithmetic mean of p_{x+1} and p_{x-1}, or p_{x-1}, p_x, p_{x+1} are in arithmetic progression. Consider p_0 as the first term of the arithmetic series and p_{m+n} as the last. The sequence of terms will then be as follows:

$$p_0+p_1+p_2+ \cdots +p_{x-1}+p_x+p_{x+1}+ \cdots +p_{m+n-1}+p_{m+n}.$$

Hence there are $m+n+1$ terms and according to the law of this series,

$$p_{m+n} = p_0+(m+n)d,$$

where d is the constant difference between succeeding terms.

But $p_{m+n} = 1$ and $p_0 = 0$, therefore,

$$1 = 0+(m+n)d, \text{ or, } d = \frac{1}{m+n}, \text{ and therefore } p_x = \frac{x}{m+n}$$

which represents Jones' chance of winning all the money at any time after the beginning of play, when he has in his possession x dollars of the total $m+n$ subject to risk. At the beginning when Jones has m dollars, the chance that he will win all and consequently ruin Smith is,

$$p_m = \frac{m}{m+n}.$$

Similarly the chance that Smith will ruin Jones is,

$$p_n = \frac{n}{m+n}.$$

Here again are two events either of which can happen, and they are mutually exclusive. Therefore, according to Proposition 2, the probability that one of them will happen is,

$$p_m+p_n = \frac{m}{m+n} + \frac{n}{m+n} = \frac{m+n}{m+n} = 1,$$

which translated from the language of probability theory into everyday English means, absolute certainty.

Hence the theorem is proved.

Again, Jones' chance of being ruined is the same as Smith's

chance of winning, namely,

$$\frac{n}{m+n} = 1 - \frac{m}{m+n}.$$

If the quantity n which represents Smith's wealth be increased indefinitely, Jones' chance of going broke differs from unity, or certainty, by less than any preassigned or any assignable quantity. When n is infinitely large, Jones is no longer betting with a person of limited means, but, in the sporting vernacular, he is "bucking the bank," or is staking his wealth against that of the world, i. e., he is a professional gambler. The above line of reasoning shows that he must ultimately be ruined, since his chance of not being ruined is less than any assignable chance.

EARTH RESISTANCE AND ITS RELATION TO THE ELECTROLYSIS OF UNDERGROUND STRUCTURES.

There has just been issued by the Bureau of Standards, of the Department of Commerce, a paper dealing with the factors which influence the resistivity of the soil and with the effects of soil resistance on the leakage of currents from street railway lines, using the rails as return conductors. Three methods of determining the specific resistance of soil are given, and the results of a large number of measurements are tabulated.

The principal factors which influence soil resistance are described and their effects on the results of electrolysis surveys and on the escape of currents from street railway tracks are discussed.

Copies of the publication, Technologic Paper No. 26, entitled *Earth Resistance and Its Relation to the Electrolysis of Underground Structures,* may be obtained free of charge upon application to the Bureau of Standards, Washington, D. C.

DETERMINATION OF BARIUM SALTS IN VULCANIZED RUBBER GOODS.

Specifications for purchasing rubber goods frequently permit the use of barytes (barium sulphate) as a mineral filler without having the sulphur which it contains count as part of the specified total sulphur. In such cases, in order properly to correct the total sulphur, the barium sulphate must be determined. The Bureau of Standards, of the Department of Commerce, has recently completed a careful study of the question and has just published the results in Technologic Paper No. 64.

When barium sulphate only is used, the amount present is readily ascertained by determining the total amount of barium present. If barium carbonate is used, it is necessary to separate the two salts. By means of tests made on compounds of known composition prepared at the Bureau of Standards, a method has been devised which permits the quantitative determination of barium carbonate in the presence of either lead sulphate or barium sulphate, the two sulphates most commonly used in rubber goods. The accuracy of the determination is satisfactory for all practical purposes.

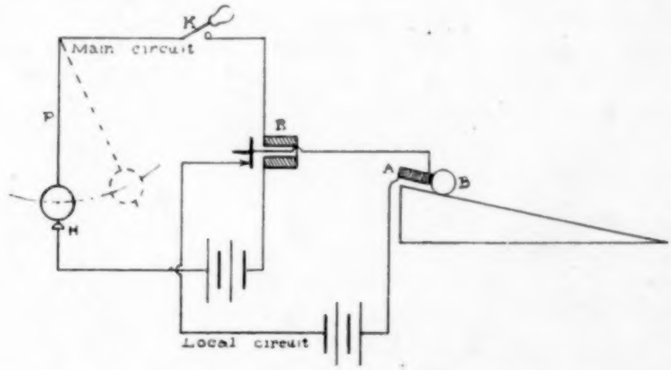
Persons interested may obtain copies of the paper, *The Determination of Barium Carbonate and Barium Sulphate in Vulcanized Rubber Goods,* free of charge from the Bureau of Standards, Washington, D. C.

MAGNETIC RELEASE FOR FALLING BODY.

By A. Haven Smith,

Polytechnic High School, Riverside, Cal.

A convenient method of illustrating many of the laws of uniformly accelerated motion is to roll a ball down an inclined plane. This method is suggested by Millikan & Gale's *First Course in Physics*. The difficulty we have always experienced with this method was the impossibility of starting the ball at the desired instant. To overcome this trouble the magnetic release, illustrated here, was devised.



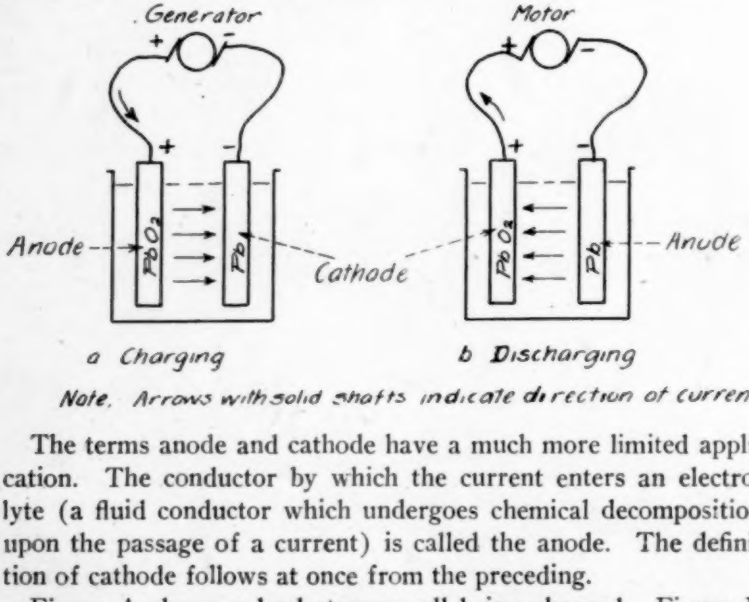
The contact points on an ordinary relay were reversed. It was then connected as shown in the drawing. The ball is adjusted and held in place on the plane by the electromagnet, A. It is clear that this circuit is closed as long as the key, K, is open. The seconds pendulum, P, is set in motion and the key, K, closed. The pendulum passing through the drop of mercury, H, completes the "main circuit," operates the relay and releases the ball. If the ball releases at all there is no question as to the time of its starting. We had some little trouble while testing out the apparatus with residual magnetism, but this was easily remedied by sticking a piece of paper on the end of the electromagnet. As long as the key, K, is closed, the relay will continue to click each second. These clicks are loud enough to be distinctly heard in any part of the classroom. We placed a block of wood on the plane and adjusted its position until the sound of the ball striking the block coincided with the desired click of the sounder. This was repeated two times. The positions of the block were marked and distances used later to deduce the laws desired.

POSITIVE AND ANODE ARE NOT SYNONYMOUS TERMS.

By Olin D. Parsons,
Yonkers High School, New York.

An article in a recent number of School Science and Mathematics brings out once more the fact that there are teachers of chemistry and physics who do not draw sharp distinctions between *positive* and *anode,* and *negative* and *cathode.* The trouble seems to be very largely in defining the terms positive and negative.

Positive, and its symbol +, when applied to the terminal of any device in an electrical circuit, means that the pole or terminal so designated is at a higher potential or electrical pressure than the other terminal, called the negative (—). All devices transforming chemical, mechanical or other forms of energy into electrical energy have their *positive* terminals at the point *where* the *current leaves.* All devices for transforming electrical energy into heat, chemical or mechanical energy have their *positive* terminals at the point *where* the *current enters.*



Note. Arrows with solid shafts indicate direction of current

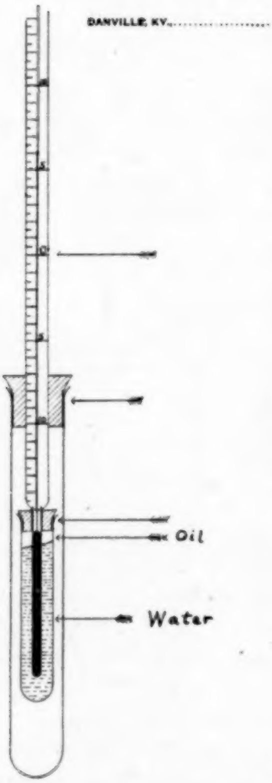
The terms anode and cathode have a much more limited application. The conductor by which the current enters an electrolyte (a fluid conductor which undergoes chemical decomposition upon the passage of a current) is called the anode. The definition of cathode follows at once from the preceding.

Figure A shows a lead storage cell being charged. Figure B shows the same cell discharging. Note that the positive (+) and negative (—) poles or terminals have not changed places, but that the anode and cathode have. For the motor we may substitute an incandescent lamp, electric bell or other device requiring electrical energy. For the generator we may substitute a

thermopile or even two similar lead cells in series. As an exercise for pupils, a diagram of three cells in series, one "bucking" two, with all anodes, cathodes, positives and negatives labeled, provokes discussion and clears up the point. The writer has found the average third-year-high-school pupil able to grasp the distinction. It leaves one thing less to be corrected later.

COOLING THROUGH CHANGE OF STATE.

By N. F. Smith,
Centre College, Danville, Ky.

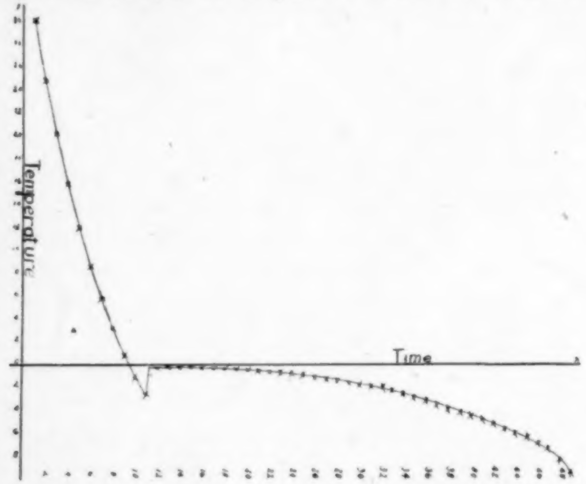


An instructive experiment commonly performed in the elementary course in physics consists in determining and plotting the curve of cooling for some substance as it passes from the liquid into the solid form. If a suitable substance is chosen, this experiment brings out clearly a number of interesting facts, such as the phenomenon of subcooling, the sudden rise in temperature upon crystallization, the constancy of temperature during the process of freezing, and the deviation from Newton's Law of Cooling.

A substance suitable for this experiment should have its freezing point sharply defined and at a convenient temperature; it should have a fairly large specific heat and a large heat of fusion; it should be inexpensive and easily obtained in a pure form. Numerous substances have been suggested and used for this purpose, such as acetanalide, acetamide, naphthaline, sodium hyposulphite, etc. All of these substances fail to meet one or more of the requirements mentioned. It seems strange that the substance which comes nearest to fulfilling the ideal conditions has been quite generally overlooked. After trying the experiment with each of the substances named above, the writer is convinced that the most satisfactory substance available is *water*.

The experiment with water has been performed as follows: A small test tube, about three inches long, is carefully cleaned

and nearly filled with distilled water from which the air has been removed by boiling. In this is inserted a thermometer having a long cylindrical bulb, graduated to tenths of a degree down to ten or twelve degrees below zero. A few drops of olive oil are then poured into the test tube to exclude the air and the tube closed by a tight-fitting cork stopper around the thermometer. The small test tube, thus suspended from the thermometer, is



placed inside a larger test tube which is likewise closed by a cork stopper around the thermometer. The whole is then immersed in a gallon battery jar filled with a freezing mixture of ice or snow and salt at a temperature of –10° or –12°. Under these conditions, the water may be cooled down regularly from room temperature or above to a temperature from –2° to –8° when it suddenly freezes, bringing the temperature back to 0°. The large value of the heat of fusion of ice keeps the temperature constant for a relatively long time, after which it falls, more and more slowly, to the temperature of the freezing mixture.

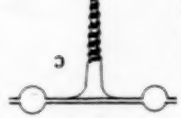
The advantages afforded by water over other substances in this experiment are the unlimited supply available, the sharpness of definition and uniformity of the freezing point, the large heat of fusion, and the increased interest which comes from the practical importance of the facts brought out.

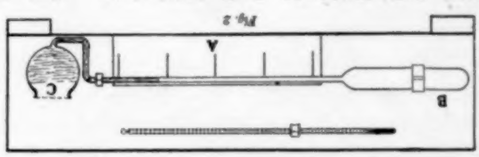
CHARLES' LAW APPARATUS.

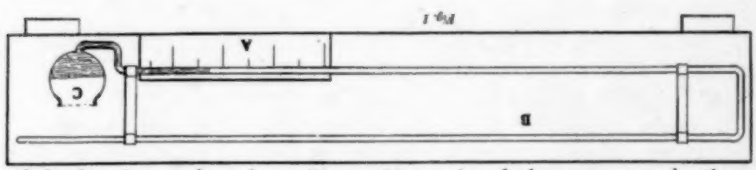
By F. R. Gorton,
Ypsilanti, Mich.

In the October, 1915, number of School Science and Mathematics, I presented a simple method for the measurement of the volume of a gas at various temperatures, to be used in the illustration of Charles' Law. Since that time, two forms of apparatus have been developed for the same purpose and are now serving as laboratory pieces.

The form shown in Figure 1 is constructed by closing one end of a long piece of glass tubing, not more than 4 mm. in diameter inside. Before bending the tube, it is filled to a point near the open end with clean mercury and the position of the end of the column marked with a file. The tube and contents are then







weighed. A portion (say 20 or 30 cm.) of the mercury is then poured out, the end of the column marked as before, and the tube weighed. By making use of the density of mercury, the volume of the tube can be readily computed and also an accurate value of the number of centimeters of length equivalent to one cubic centimeter can be found. The tube is now sealed or attached with a rubber tube, preferably the former, to a thistle tube, C, whose stem is bent as shown in the cut. After the tube is bent into the form of a long U, it is attached to a simple base by means of screw clips as shown in cut C. A thermometer is also attached to the base by a screw clip like cut D.

The space between the two file marks can now be graduated on a cardboard strip mounted on a long block placed just below the tube. The divisions of the scale should read in cubic centimeters of volume. The units can be divided into tenths, easily readable to hundredths.

The apparatus is put into working order by pouring concentrated sulphuric acid into the thistle tube and then slightly warming the long tube, B, with a lighted match in order to drive out a small portion of the confined air. This process should be carried on until the end of the column of acid at A stands near the upper limit of the scale at room temperature. The acid now serves both as an index and a drying agent.

Figure 2 shows a more compact form in which a bulb, B, containing about 15 cubic centimeters of air takes the places of the long U tube in Figure 1. The calibration of the tube is carried out in precisely the same manner, and the method of filling and using it is the same. In either case, the confined air and thermometer come to the temperature of the surrounding air more promptly if the parts are mounted in clips an inch or more from the wooden base.

The process of using these instruments consists in taking readings of the volume of the air enclosed in the tube simultaneously with the thermometer in the classroom and outside the building. Thus in winter, variations of as much as 30 degrees are easily obtainable. Volume changes of two or three cubic centimeters can be easily secured. On account of the large area of the liquid surface in the thistle tube, a movement of the acid several centimeters does not materially alter the height of the liquid, and hence the pressure remains constant.

AN INTERESTING EXPERIMENT ON BUOYANCY.

By R. C. Hummell,

Department of Chemistry, Ohio State University.

Many very interesting and instructive variations of some of the simplest experiments in science are missed by the instructor as well as by the student. Most textbooks, also, because of the necessity of economizing space, leave a great many things to be inferred. For these reasons, a student may be quite familiar with the facts concerning a certain scientific principle as stated in the textbook and yet be quite confused if a question arises concerning some variation of the principle. The following discussion and experiment furnish a good example of the above statements.

Most textbooks in physics present the Principle of Archimedes in some such way as the following: A solid, immersed in a liquid, is buoyed up by a force equivalent to the weight of the liquid displaced. In Watson's *Textbook of Physics* the forces acting on a solid immersed in a liquid are enumerated as follows: First, the pull of gravity on the body, acting downward; second, the force equivalent to the weight of the column of liquid over the top of the body, acting downward; and third, the force equivalent to the weight of a column of liquid of the same horizontal cross section as the body and extending from the upper surface of the liquid to the bottom of the object, acting upward on the lower surface of the object.

Now, if the sum of the first two of these forces is less than the third the object will float, while if the third is less than the sum of the first two the object will sink.

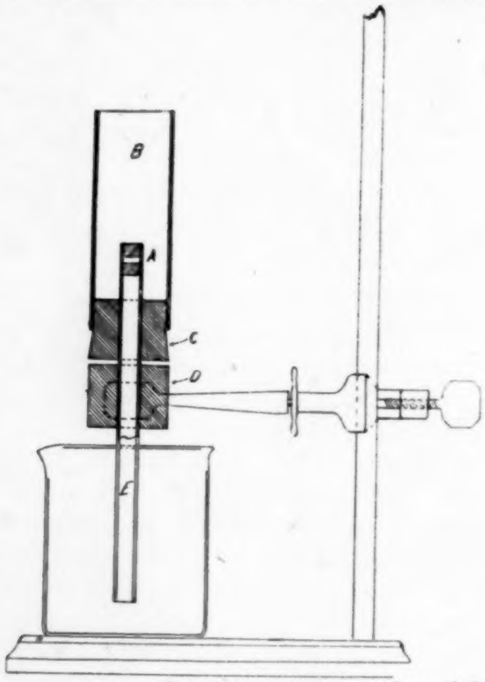
This being about all that is usually given, it is quite to be expected that the average student should go astray when the following interesting variation of this principle is presented:

Suppose a light object, such as a cork stopper, having a plane face, be placed on the bottom of a beaker or other vessel with a plane bottom and mercury be poured around the object, will it remain on the bottom as the mercury rises around it or will it float? It is rather surprising how few persons will answer otherwise than that the object will float. If a demonstration be given of the fact that the object remains on the bottom of the vessel, and the question be raised as to why it does so, the answer is apt to be that the air pressure on top of the object holds it down, and indeed this would be sufficient if the object and vessel are in very good contact.

If we notice again the statement of the forces acting on a body immersed in a liquid, we observe that the third force acts upward on the bottom of the object. Now if the object is resting on the bottom of the vessel in such close contact that the liquid can not get under it, this third force becomes zero, hence there is no upward force at all.

In order to demonstrate these facts the accompanying simple apparatus was devised. (See figure.) B represents a glass cylinder, which may be of any size so that there is ample room between its walls and A to admit the stem of a small glass funnel; C is a one-hole stopper supporting the glass tube E, which is open at both ends; A is a section of glass tubing which is closed at each end with some light substance such as cork, and is of same diame-

ter as E or slightly smaller. The upper end of E and the lower end of A should be carefully ground so as to have plane faces. The open tube E is used as a support for A in order that air pressure may operate on the bottom as well as on the top of A and thus show that it is not necessarily air pressure that causes the object to remain on the bottom. D is a one-hole stopper



which serves as a support for the apparatus. Any light cylindrical object, such as cork, may be used for A, provided it has a plane base and stands perpendicular to its support. The glass plug, however, is reccommended, as it is neat, easy to make, and is also quite buoyant in mercury. If an ordinary cork stopper is used it will remain in position as the mercury rises in the cylinder, provided the larger end of the cork serves as base. If the small end of the cork serves as base the cork will float, due to the fact that the under surface of the enlarged part of the cork is exposed to the mercury.

Having placed the plug A carefully in place, pour the mercury through a funnel extending to the bottom of B, until it comes up over the top of A. Until it reaches the top of A, only the first of the above stated forces is operating. After it covers A, the first two forces are operating. At no time does the third force operate, since the mercury can not get under the plug.

THE CHIEF OBJECT OF HIGH-SCHOOL CHEMISTRY.

By O. L. Brauer,
Selma, California.

Various reasons are given for teaching chemistry in the high school. Among these are: To prepare for college; to discipline the mind; to teach the scientific method; to teach the student to be more observing of nature; to give him a better understanding of natural phenomena; and to impart more or less useful information. All these are well and good, but it seems to me the greatest thing to be accomplished by high-school chemistry has been overlooked; that is, to show the great dependence of all national and industrial advancement and all industries upon science and scientific research, and the great necessity of supporting chemical research and its applications in every possible way.

Statistics show that, on the average, about one in ten of the graduates of the high schools go to college, and many of these do not take any more chemistry. Hence it is obvious that the preparation for college should only be incidental to the main object of the course. If you examine those persons who had only preparatory chemistry about ten years ago, you find that they remember little more than that water is H_2O and sulphuric acid is H_2SO_4. The imparting of useful information, then, can only be a small part of the purpose of the course, since so little of it is retained. The other secondary objects of the chemical course are of unquestionable value, yet nevertheless secondary, to the main purpose.

The need of chemical enlightenment can best be expressed by a quotation from an address by Arthur D. Little, Massachusetts Institute of Technology, published in the January (1916) number of the *Journal for Industrial and Engineering Chemistry:*

"There is a great need at the present time on the part of bankers, capitalists, men of affairs, and directors of industry, and in no less degree on the part of superintendents, foremen, work people, and the public generally, for a better appreciation of the part which science plays in furthering industrial development, increasing the efficiency of production, raising the scale of wages, and insuring preparedness, whether for peace or war.

"This need arises from the fact that men of affairs, and especially financiers, have seldom received a scientific training or acquired a working knowledge of the scientific method or fully understood the scientific point of view. They consequently often

fail to realize the intrinsic merit of industrial propositions which are based essentially upon new applications of applied science, and to gauge with accuracy their chances of success.

"They can, it is true, employ specialists, as in fact they should do in any case, but they often cannot weigh the validity of expert reports, because of ignorance of the scientific method and suspicion of the value of its deductions. As a result of these too common limitations in financial circles, the development of large and ultimately highly profitable industrial undertakings is often postponed for years.

"The directors of industry—though happily with many notable exceptions, especially among those to whom have been entrusted the affairs of our largest corporations—frequently ignore science. Willfully or unconsciously, they cut themselves off from that great accumulation of coordinated knowledge and organized common sense which has been painfully built up by thousands of the best minds in every land during the last hundred years.

"Proposals based on the scientific study of a problem or situation are, therefore, often rejected by these gentlemen as "theoretical" because the man who prides himself on being "practical" either cannot absorb the data or does not dare to trust himself to the conclusions. Thus antiquated methods persist, avoidable wastes continue, and dividends decline.

"The attitude of superintendents and foremen and of the industrial workers generally to the innovations and betterments proposed by science is far too commonly one of militant skepticism or hostile suspicion."

American Industry has grabbed for large and quick returns from the exploitation of our natural resources. The time is about past when a man, by a clever turn, can appropriate to himself the vast resources of the country and amass a colossal fortune without contributing proportionally to the wealth of the nation. Many of the American industries have been characterized by profligate waste. The time has arrived when "Conservation" is the slogan, and profits must come as much from the utilization of the by-products as from the old-line business. This will require scientific research and applied science more and more. Business is learning and must learn much faster that knowledge and science are valuable and must be paid for. President McLauren, of Massachusetts Institute of Technology, says if one tenth of the scientific knowledge now in textbooks were rightly applied fortunes would be made every year.

Germany has learned to pay for science and research, and all the world has been paying her homage industrially. American minds are just as bright as those of the Germans. We could have anything if we would pay for it. The German industries have been profitable. Industries that were planned to yield fifteen per cent profits years ago have developed under the investigators until before the war they were paying thirty per cent profit. C. F. Chandler, in a recent address, pointed with considerable amusement to the announcement which New York newspapers made with great pride that a factory for synthetic dyes was to be built on Long Island on a 40x70-ft. lot. They heralded this as something extraordinary. Prof. Chandler contrasted this with F. Bayer & Company's plant in Germany, covering a square mile of ground, which ten years ago employed 300 chemists and 8,000 workmen—a company with over fifty-three years' experience at making synthetic dyes.

The recent proposal of a five million dollar research or testing laboratory for the U. S. Navy is opposed by many as an extravagance. Baekaland, of the Naval Consulting Board, points out that it is far better to make the mistakes in the laboratory at the cost of a few thousand dollars than in the Navy at a cost of millions. He points out that two million dollars is lost annually by corrosion in condenser tubes in our warships. If one million in research could prevent this, which it no doubt could, a million would be saved. This is just one small illustration of the many similar problems confronting the Navy.

The past history of American enterprise shows many large-scale failures that might easily have been averted by a few thousand dollars spent in scientific investigation. An illustration that came to my notice is from a plant for making grape juice at Lodi, California. At this place a plant was erected at an expense of about $200,000. The company fell through and the plant stopped because they couldn't clarify the juice. A good research chemist in a year's time could have settled that question one way or the other and prevented the loss. In fact, professors at the University of California have recently perfected methods that they believe would have clarified that very juice. In spite of thousands of similar examples over the United States, there are scores of Ph. D.'s that can scarcely find suitable employment at $100 per month; men who are almost geniuses and capable of first-class research.

The universities are longing to plunge in and help on all these

problems, but because of lack of funds and opportunity they can only help in a meager way. Men of the highest ability and training, with Ph. D. degrees, are asked to teach in our universities at salaries from $900 to $1,200 per year. This condition is shameful. It is an insult to the teaching profession; it is a shameful lack of appreciation of what science and scientifically-trained men could do for the country. We pretend by our patent laws to encourage inventions and discoveries. I have in mind men scientifically trained who have roughly outlined very important inventions, but because of the pressing necessity of making a living and supporting a family must lay these away. Capitalists are very skeptical, as yet, of the possibilities of research. A thing must be a demonstrated certainty before they will touch it, and then they are scarcely willing to pay its lowest worth. To perfect an invention or a process sometimes takes years of undivided attention. It is only the person in unusual circumstances who can do this.

Such are the conditions. How are the bankers, the capitalists, the men of affairs, the directors of industry, the superintendents, foremen, the working people and the thinking public going to be taught the value of scientific knowledge and the necessity of paying for it? The most direct way, it seems to me, is through the high schools. The bankers, capitalists, etc., of tomorrow are in the schools of today. If the high-school science gave its students a real understanding of the part science could and should play in our country, the task would be mostly done. Why do students take science if not to learn what science means and what it has to offer? Why is it put in the schools? Do the patrons of the schools care anything about the allotropic forms of arsenic or the oxides of chlorine? What they want to know is if it be wise to establish national research laboratories; to endow scientific schools; or whether it be wise to invest in such or such an enterprise; or can such and such a thing be accomplished; whom can we get to accomplish it; and why has Germany led the world in so many industries.

The greatest thing high-school science should accomplish is to show the student the great significance of science, the field of any particular science and what its knowledge means and can hope to do. In chemistry let us drop all irrelevant and purposeless descriptive parts and substitute the real spirit and enthusiasm of chemistry in its place.

LIVE CHEMISTRY.

By G. Ross Robertson,
Polytechnic High School, Riverside, Cal.

Obtain a supply of grocery-store ammonia, and one of concentrated ammonia from a local drug store. Note prices of each in pint or quart quantities.

Let a number of students choose 15 cc. samples of either, and dilute to one-fifth the strength, i. e., add exactly 60 cc. water. If accurate graduates are not at hand, instructor may dilute a stock supply of each under the eyes of his class, still reserving a generous sample of the original article for the class to investigate in a general way qualitatively. Dilution is performed to avoid noxious odor.

Set up two burettes; call the first "A" for acid, and the right-hand burette "B" for base. Alphabetical order, A-B, helps student in keeping figures straight.

Let instructor prepare a normal HCl solution, explaining that it contains 36.5 g. HCl in one liter of solution. A supply of this is placed in burette A. For this experiment it will be allowable to dilute the present-day "C. P." hydrochloric acid by hydrometer data, or even by consultation of the "analysis" label. Accuracy of the method will likely exceed accuracy of the high-school student; moreover the standard acid is used largely for comparison of the two bases, where errors are compensated.

Fill burette B with the chosen sample, diluted as above. With methyl orange as indicator, students should practice titration with 3 or 4 cc. amounts until (1) they understand the color changes, (2) they have the approximate ratio, which guides them in the actual titration, preventing an overdose of the strong solution and consequent delay due to refilling burette. Instructor should accept no titration ratios where the volume read is less than 7 cc. After the first end-point is reached, student should record figures and let out a few more drops ammonia. A second determination of end-point is made, followed by at least three others, to test accuracy.

Data and calculations (sample figures, grocery ammonia):

Vol. acid	Vol. ammonia	Acid/Base
7.2 cc.	28.4 cc.	.25—
9.7 cc.	38.8 cc.	.250
etc. —	etc. —	etc. —

Equation:

$$NH_4OH \text{ plus } HCl = NH_4Cl \text{ plus } H_2O$$
$$(35) \qquad (36.5)$$

A liter of ammonia which was of the same "strength" as the "normal" acid must contain 35 g. ammonium hydroxide. This sample as diluted is but .250 as strong, so contains 8.75 g. hydroxide. The undiluted liquid is five times stronger, or 43.75 g. per liter.

(A second student, working with commercial "concentrated" ammonia, finds a concentration more like 400 g. per liter. Suppose the retail price of this is 25c per pint, and of grocery ammonia 10c per pint. Class sees the economic side of the thing.)

A FEW THEORIES OF MODERN CHEMISTRY.

By Robt. W. Boreman,[1]
High School, Parkersburg, W. Va.

The iconoclast has a much simpler job than has the reformer. Almost any of us can criticize and tear down existing beliefs, but we wait for the man of genius to do the reconstruction work; to advance the new hypotheses or to discover new laws.

The writer lays no great claim to originality in this article, but, feeling that some of the old premises are no longer tenable in the light of modern scientific knowledge, would point out some places where there have been fallacies in our reasoning, and possibly remedy, in one or two instances, the confusion arising from keeping certain of the old terms in with the new.

Let us learn the chemical fundamentals well, and then to a very great extent do away with the old cook-book methods. We have learned chemical facts by rote until we are in danger of forgetting that chemistry is a science. The study of physical chemistry is doing much to restore chemistry to its proper position as a science. Let us not simply learn facts, but do our best to discover general laws governing nearly every case, as the physicist has done. Chemistry should not be treated as a distinct subject but really as a branch of physics.

One of the old words that acts as a thorn in the side of the modern chemist is *oxidation,* bearing as it does all sorts of misleading implications.

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[1]For several of the ideas herein expressed the writer desires to thank Prof. McPherson of the Ohio State University; Prof. H. T. Beans of Columbia, and Prof. Julius Stieglitz of the University of Chicago.

To make oxidation clear let us use the compounds of iron for an example. Take all the iron compounds possible and find the ones that are soluble in water. Next find what ones of these will conduct the electric current. Let us classify still farther and find what ones from this last group will give a blood-red precipitate with potassium thiocyanate, and we still have a large number (the ferric salts). The others give no blood-red color with potassium thiocyanate (KCNS). Potassium ferrocyanide makes all that were red above change to a deep blue color (Prussian blue), while those that were comparatively unaffected above by the potassium thiocyanate now are changed to a light blue color. Potassium ferricyanide forms a reddish brown color with this first group of iron compounds and a rather deep blue with the latter group of iron compounds. Let us call the first group of iron compounds *alpha* iron and the second group *beta* iron, forgetting the words ferric and ferrous for the present, as they have old and incorrect associations in our minds. We soon reach the conclusion that the above color changes depend upon whether the iron is alpha iron or beta iron in the solution in which we are making the test.

Take some of the beta iron and add a little potassium permanganate, which loses its color, and then add some potassium thiocyanate and a deep red color is produced, which was the test that we had above for the alpha iron, so evidently in some way the potassium permanganate has changed our beta iron to alpha iron.

Take a solution of alpha iron and divide it into two portions. To one portion add potassium ferricyanide ($K_3Fe(CN)_6$) solution and a brown color is produced; to the other portion add some potassium iodide (KI) and then add some of the ferricyanide to it and a deep blue color is produced, indicative of beta iron. Evidently the KI in this case and the $KMnO_4$ in the preceding have produced opposite changes in our iron. Next let us take a solution of beta iron in which there is some potassium thiocyanate (KCNS), and a red color appears if we pass the electric current through the solution. The red forms at the negative electrode, toward which the iron ions are moving. This shows that, while there may have been considerable circumlocution in the mixing of our compounds, yet the change that takes place is probably electrical in its nature.

Experimentally we can prove the above as follows: Take a number of beakers filled with diluted sulphuric acid and con-

nected by "salt bridges" (U-tubes filled with a solution of sodium chloride and closed at both ends with plugs of filter paper). Add potassium permanganate to the beaker on one end and some beta iron to the beaker on the other end, also some potassium thiocyanate (KCNS) solution. Take two electrodes and insert them in the end beakers, and connect them together by a wire. If we introduce a delicate galvanometer into the circuit there will be a deflection of the needle, showing that an electric current is flowing, and a red color in the beaker containing the beta iron shows that it is changing into the alpha state. We find quantitatively that when the atomic weight in grams or 55.8 grams of iron are changed from the alpha state to the beta it takes 96,500 coulombs of electricity. When current is passed through hydrochloric acid we find the hydrogen moving towards the negative electrode, so it must be positively charged, and changes from the ionic state to hydrogen gas. In this case it takes 96,500 coulombs of electricity to change the atomic weight of the H in grams from hydrogen ions, or H^+, to the element hydrogen, or H. Alpha iron contains three times 96,500 coulombs on 55.8 grams of the iron. If we wish to represent 96,500 coulombs of positive charge on iron, let us represent it by Fe^+, or two times 96,500 coulombs by Fe^{++}, etc. Then alpha iron is Fe^{+++}, beta iron is Fe^{++}, and metallic iron is Fe^0. They differ only in their energy content. So let us call the alpha iron (Fe^{+++}) ferric iron, and the beta iron (Fe^{++}) ferrous.

Since in changing from the "ic" to the "ous" state we reduce the available energy or charge of an element, there is nothing misleading in the old term "reduction," but the change from the "ous" to the "ic" state is simply an indication of an increase in the electrical energy content of a given element, so obviously the term oxidation is a misnomer, since it would seem to imply that oxygen was necessary. A year or two ago several chemists met together to see if this term might not be changed. After considerable argument a new term was adopted, but has not yet come into general use. The term they chose in place of "oxidation" was "adduction," as the opposite of reduction.

If we bubble oxygen through a solution of ferrous sulphate and sulphuric acid the iron is not changed to the ferric state but when the oxygen is furnished from the reaction shown by this equation $2KMnO_4+3H_2SO_4 = K_2SO_4+2MnSO_4+3H_2O+5O$, we have the equation which is generally accepted, $2FeSO_4+H_2SO_4+O = Fe_2(SO_4)_3+H_2O$, so the term "nascent" was in-

vented to indicate a newly liberated substance, and this change has long been attributable to nascent oxygen. However, if you take two beakers, the one containing $FeSO_4$ and H_2SO_4, and the other containing $KMnO_4$ and you complete a circuit through them with a wire, the iron is changed to the ferric state. Now it cannot be maintained that the oxygen hurried along the wire from one solution to the other, yet the iron is "adduced" or "oxidized" without the oxygen reaching it, the only change being electrical. So the terms nascent oxygen, and its brother, nascent hydrogen, have become almost obsolete.

Combining the equations above showing adduction, we have the equation $2KMnO_4+10FeSO_4 + 8H_2SO_4 = 5Fe_2(SO_4)_3 + 2MnSO_4+K_2SO_4+8H_2O$. Let us rewrite the above equation, leaving out all the parts that do not change (they being no more necessary than telling whether we do the experiment in an evaporating dish or a test tube), and we have the equation $MnO^- + 8H^+ = Mn^{++} + 4H_2O$, and there are five charges not accounted for, each one representing 96,500 coulombs of electricity. We have already discovered that the change from the ferrous to the ferric state was a change represented by Fe^{++} to Fe^{+++}, so we can balance the equation by writing:

$$\begin{array}{c} MnO_4^- + 8H^+ \rightarrow Mn^{++} + 4H_2O \\ 5Fe^{++} \rightleftharpoons 5Fe^{+++} \\ \hline 5Fe^{++} + MnO_4^- + 8H^+ \rightleftharpoons Mn^{++} + 4H_2O + 5Fe^{+++}. \end{array}$$

This equation balances electrically and really shows what takes place.

In the writer's humble opinion physical chemistry is the chemistry of the immediate future, and until chemistry is put on the same basis as physics it will remain more a memory test than a science.

MARKING CRUCIBLES.

By J. E. Huber,

Peoria, Ill.

A number of contributors on marking crucibles have given different methods, but the simplest of all is to use a grease blue pencil, one made with Berlin blue as the coloring material.

All that is necessary is to mark your crucible and place it over a Bunsen burner, heat to redness, and it's done. The mark will be brown, due to ferric oxide fused into the glaze, and if done properly is permanent.

PROBLEM DEPARTMENT.

By J. O. Hassler,
Englewood High School, Chicago.

Readers of this magazine are invited to propose problems and send solutions of problems in which they are interested. Problems and their solutions will be credited to their authors. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.

Algebra.

461. *Proposed by Claude O. Pauley, Linden, Ind., and William E. Curtis, Somerset, Mass.*

Solve the equations:

$$x^2+y = 7 \qquad (1)$$
$$y^2+x = 11 \qquad (2)$$

[Editor's Note: Mr. Anning has called attention to the fact that this problem as No. 230 was proposed and solved in Vol. XI, p. 266, of SCHOOL SCIENCE AND MATHEMATICS. Lacking a set of back numbers, the editor was not aware of this fact. Mr. Roray calls attention to a solution on page 576 of Fisher and Schwatt's textbook of algebra. The solutions submitted to the editor in general followed the plan of finding the integral root of the quartic, which appears when x or y is eliminated, by factoring and using either Horner's or Cardan's method to find the three roots of the cubic which remains. The two solutions published below are different.]

I. *Solution by Elmer Schuyler, Brooklyn, N. Y.*

This problem has been solved in many ways in former numbers of the *American Mathematical Monthly*. The general solution of a pair of equations

$$x^2+y = a$$
$$y^2+x = b$$

depends upon the solution of a biquadratic in one unknown.

If the given equation has a pair of positive integral roots, the following solution may be original.

Subtract eq. (1) from (2), then $y^2-x^2-y+x = 4$.
Or $(y-x)(y+x-1) = 4$.

Since x and y are each $\geqq 1$, and $y+x-1 > (y-x)$ because the inequality gives $2x > 1$.

Hence

$$y-x = 1$$
$$y+x-1 = 4$$

and $y = 3$ and $x = 2$. The other solutions depend upon a cubic equation.

II. *Solution by E. K. Whiton, Pueblo, Colo.*

$$x^2+y = 7 \qquad (1)$$
$$y^2+x = 11. \qquad (2)$$

Substituting values of y found from (1) in (2),

$$x^4-14x^2+x+38 = 0. \qquad (3)$$

By inspection $x_1 = 2$.
This leaves the equation

$$x^3+2x^2-10x-19 = 0 \qquad (4)$$

to be solved.

Since there is one variation in sign (4) may have one positive root. This lies between 3 and 4.

By Horner's method of approximation this root is:

$$x_2 = 3.1313.$$

If x_3 and x_4 represent the other two roots,

$$x_3+x_4 = -5.1313, \tag{5}$$

$$x_3x_4 = 6.0678. \tag{6}$$

Solving (5) and (6) the roots are

$$x_3 = -3.2831,$$

$$x_4 = -1.8481.$$

By substitution in (1)

$$y = 3, \quad -2.805, \quad -3.7787, \quad 3.5844.$$

All of these values satisfy (2).

III. *Answers to ten decimal places by Charles Marsh, Ainsworth, Ia.*

x	y
2.	3.
3.1313125182	—2.8051180866
—3.2831859913	—3.7793102534
—1.8481265269	3.5844283405

462. *Proposed by Harry C. Carver, Shortridge High School, Indianapolis, Ind.*

Eliminate x from the equations:

$$\frac{\cos(a-3x)}{\cos^3 x} = \frac{\sin(a-3x)}{\sin^3 x} = b.$$

I. *Solution by Norman Anning, Chilliwack, B. C.*

$C \equiv 4\cos(a-3x) = 4b\cos^3 x = b(\cos 3x+3\cos x),$

$S \equiv 4\sin(a-3x) = 4b\sin^3 x = b(-\sin 3x+3\sin x),$

$C+iS = 4e^{i(a-3x)} = b(e^{-3ix}+3e^{ix}).$

Multiplying by e^{3ix},

$$4e^{ia} = b(1+3e^{4ix}).$$

$$4e^{ia}-b = 3be^{4ix}.$$

$$4e^{-ia}-b = 3be^{-4ix}.$$

$$16-4b(e^{ia}+e^{-ia})+b^2 = 9b^2,$$

$$b^2+b\cos a-2 = 0.$$

Note: This solution seems to be somewhat more direct than that given by Mr. Babbitt on p. 246 of Vol. XV. That given on page 457 is shorter but contains a slight error since

$$\sin a = \tfrac{3}{4}b\sin 4x \neq \tfrac{1}{4}b\sin 4x$$

as given.

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

$$\frac{\cos(a-3x)}{\cos^3 x} = b \tag{1}$$

$$\frac{\sin(a-3x)}{\sin^3 x} = b \tag{2}$$

These equations may be written thus:

$$\frac{\cos(a-3x)}{\cos x} = b\cos^2 x \tag{3}$$

$$\frac{\sin(a-3x)}{\sin x} = b\sin^2 x \tag{4}$$

Adding we have

$$\frac{\sin(a-2x)}{\sin 2x} = \frac{b}{2}$$

or

$$\tan 2x = \frac{2\sin a}{b+2\cos a} \tag{5}$$

Subtracting (4) from (3) we have

$$\frac{\sin(4x-a)}{\sin 2x} = \frac{b}{2}\cos 2x.$$

$$\text{or} \qquad \tan 4x = \frac{2\sin a}{4\cos a - b}$$

$$\frac{\tan 2x}{1-\tan^2 2x} = \frac{\sin a}{4\cos a - b} \qquad (6)$$

Substituting (5) in (6) and simplifying,

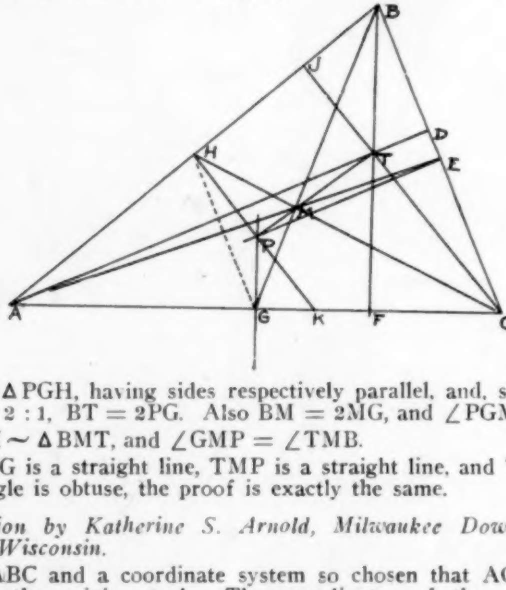
$$b^2 + b\cos a = 2.$$

Geometry.

463. *Proposed by Richard S. Beardsley, Englewood High School, Chicago, and George Raynor, Seattle, Washington.*

The medians of a triangle meet in the point M, the altitudes in the point T, and the perpendicular bisectors of the sides in the point P. Prove that points M, T and P are collinear and that M divides the line segment so that PM : MT : : 1 : 2.

I. *Solution by Richard S. Beardsley.*



ΔBTC $\sim$ ΔPGH, having sides respectively parallel, and, since ratio of similitude is 2 : 1, BT = 2PG. Also BM = 2MG, and $\angle$PGM = $\angle$MBT. $\therefore$ ΔPGM $\sim$ ΔBMT, and $\angle$GMP = $\angle$TMB.

Since BMG is a straight line, TMP is a straight line, and TM = 2MP. If the triangle is obtuse, the proof is exactly the same.

II. *Solution by Katherine S. Arnold, Milwaukee Downer College, Milwaukee, Wisconsin.*

Given ΔABC and a coordinate system so chosen that AC lies in the x-axis with the origin at A. The coordinates of the vertices are: $A \equiv (O, O)$, $B \equiv (b, c)$, $C \equiv (a, O)$. Let E, G, H be the mid-points of the sides BC, CA and AB, respectively.

$$E \equiv \left(\frac{a+b}{2}, \frac{c}{2}\right), \quad G \equiv \left(\frac{a}{2}, 0\right), \quad H \equiv \left(\frac{b}{2}, \frac{c}{2}\right).$$

Equation of BG:

$$2cx + (a-2b)y = ac.$$

Equation of CH:

$$cx + (2a-b)y = ac.$$

Solving for the intersection, we get the coordinates of M to be $\left(\frac{a+b}{3}, \frac{c}{3}\right)$.

Equation of GP:

$$x = a/2.$$

Equation of HP:

$$2bx+2cy = b^2+c^2.$$

Hence the coordinates of P are

$$\left(\frac{a}{2}, \frac{b^2+c^2-ab}{2c}\right).$$

Equation of BT:

$$x = b.$$

Equation of CT:

$$bx+cy = ab.$$

The coordinates of T are

$$\left(b, \frac{ab-b^2}{c}\right).$$

Equation of line through M and T:

$$(3ab-3b^2-c^2)x+(ac-2bc)y+bc^2+b^3-a^2b = 0.$$

Substituting the coordinates of P in this equation we find $0 = 0$.

∴ M, T and P are collinear.

In the familiar formula

$$x = \frac{m_1x_2+m_2x_1}{m_1+m_2}$$

we substitute $\dfrac{a+b}{3}$ for x, b for x_2 and $a/2$ for x_1 and obtain

$$\frac{a+b}{3} = \frac{m_1b+m_2/2}{m_1+m_2},$$

whence

$$2m_1 = m_2, \quad \text{or} \quad \frac{m_1}{m_2} = \frac{1}{2},$$

and the same result follows if we use the ordinates.

∴ PM : MT = P : 2.

464. *Proposed by N. P. Pandya, Sojitra, Dt. Petlad, India.*

The symmedian point, the nine-points center and the point of concurrence of the joins of the vertices with the points of contact of the incircle on the opposite sides are known. Show how to construct the triangle.

No solution has been received.—Editor.

465. *Proposed by Clifford N. Mills, South Dakota State College Brookings, S. D.*

Given an angle and two points A and B between the sides of the angle. Show how to find the shortest path from A to B that touches both sides of the angle.

Solution by Norman Anning, Chilliwack, B. C.

Let LOM be the angle *and suppose it less than 60°.**

Construct B_1, the image of B in OM,

Construct B_2, the image of B_1 in OL,

Construct B_3, the image of B in OL,

Construct B_4, the image of B_3 in OM.

Then AB_2 is the length of the shortest path from A to B which touches first OL and then OM. AB_4 is the length of the shortest path which touches OM first. The shorter of these two is the required minimum.

To prove the statement about AB_2:

Let AB_2 cut OL in C.

Let CB_1 cut OM in D.

Then, by construction,

$AB_2 = AC+CB_1 = AC+CD+DB$, the length of a path from A to B. And it is the shortest of all those which touch OL first.

For, choosing in OL any point P, other than C, the shortest distance from P to B which touches OM is PB_1 which is equal to PB_2. Adding AP, the shortest path *via* P is

$$AP+PB_2 \text{ which is greater than } AB_2.$$

A similar proof applies to AB_4.

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*When the angle LOM $> 60°$ A and B can be so placed in it that AB_2 cuts OM before it cuts OL and the above construction fails.

[Editor's Note: The other solutions of this problem were considered incorrect in that the solvers failed to exclude the cases where their constructions failed to give results. A complete solution of the problem would involve the determination of the conditions governing the possibility of any proposed construction. There are further interesting results to be had in this problem. See problem 480 in the list of proposed problems on the next page.]

448. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

Given the sides of a triangle equal to a, b, c, respectively, to find the area of its pedal triangle in terms of these sides.

I. *Solution by G. Subrahmania, student in H. H. The Maha Raja's College, Trivadium, South India.*

Given triangle ABC. Let the altitudes from A, B, and C meet the opposite sides in D, E, and F. BFEC is cyclic.

$$\therefore\ \overline{CF}\cdot\overline{BE} = \overline{FE}\cdot\overline{BC}+\overline{BF}\cdot\overline{CE}. \qquad \text{(Ptolemy's Theorem)}$$

$$\therefore\ \overline{FE}\cdot a+\overline{BF}\cdot\overline{CE} = \overline{CF}\cdot\overline{BE}.$$

$$\tfrac{1}{2}c\cdot\overline{CF} = \Delta, \text{ the area of the triangle.}$$

$$CF = \frac{2\Delta}{c}\cdot \quad \text{Similarly } BE = \frac{2\Delta}{b}, \text{ etc.}$$

$$\therefore\ FE\cdot a+\sqrt{(a^2-\overline{CF}^2)(a^2-\overline{BE}^2)} = \frac{2\Delta}{c}\cdot\frac{2\Delta}{b}\cdot$$

$$\therefore\ FE = \frac{4\Delta^2-\sqrt{(a^2c^2-4\Delta^2)(a^2b^2-4\Delta^2)}}{abc},$$

where $\Delta = \sqrt{s(s-a)(s-b)(s-c)}$, $\quad s = \tfrac{1}{2}(a+b+c)$.

Similarly we find ED and DF. Then by applying the formula $\Delta = \sqrt{s(s-a)(s-b)(s-c)}$ we can find the area of the triangle DEF in terms of a, b and c.

$$\text{Area DEF} = \sqrt{s(s-a)(s-b)(s-c)}\left[\frac{(b^2+c^2-a^2)(c^2+a^2-b^2)(a^2+b^2-c^2)}{4a^2b^2c^2}\right]$$

II. *Solution by Clifford N. Mills, South Dakota State College, Brookings, S. D.*

Given any triangle ABC having sides a, b and c. Let K be its area, and R its circumradius. The altitudes from the vertices A, B and C meet the opposite sides in D, E and F. Then DEF is the pedal triangle. Let $EF = a'$, $DF = b'$, $DE = c'$, K' be the area of the pedal triangle, and R' its circumradius Now since the points D, E and F lie upon the nine-point circle of the triangle ABC,

$$R' = 1/2\,R.$$

But

$$R = \frac{abc}{4K} \text{ and } R' = \frac{a'b'c'}{4K'}\cdot$$

Hence

$$K' = \frac{2Ka'b'c'}{abc}\cdot$$

It is easily proven that

$$a' = a \cos A,$$
$$b' = b \cos B,$$
$$c' = c \cos C.$$

Therefore

$$K' = 2K \cos A \cos B \cos C.$$

K, cosA, cosB and cosC are readily expressed in terms of a, b and c.

If one angle should be obtuse the value of K is negative; but the absolute value of $(-K')$ is the same as K', therefore the solution can be applied to any triangle.

CORRECTION.

Nelson L. Roray makes the following correction of his solution of problem 455 on page 262 in March issue. "I have said $\sin(\lambda+a) = 0$ gives a minimum value instead of $\sin(\lambda+a) = -1$.

Putting this value in (A) we would get

$$\lambda - a = \sin^{-1}\left(\frac{\cos \epsilon - 1}{\cos \epsilon + 1}\right) \text{ a minimum}$$

whence

$$\lambda = \tan^{-1}\left(-\frac{1}{\sqrt{\cos \epsilon}}\right)$$

This is not the problem to which we referred in proposed problem 470 in the same issue.—Editor.

CREDIT FOR SOLUTIONS.

448. Norman Anning, Aaron Freilich, Violet Grinols, Clifford N. Mills, G. Subrahmania. (5)
456. Three incorrect solutions.
457. P. N. Bragg, Herbert N. Carleton, Edward Fleischer, Florence Pinney. (4)
458. P. N. Bragg, Mabel G. Burdick, Aaron Freilich, Nelson L. Roray, Yeh Chi Sun. (5)
459. Herbert N. Carleton, Edward Fleischer, Yeh Chi Sun. (3)
460. Yeh Chi Sun. (1)
461. Mabel G. Burdick, Frank C. Gegenheimer, Myra J. Howes, William W. Johnson, M. Helen Kelley, Murray J. Leventhal, Roy W. Lord, Charles Marsh, F. M. Phillips, Nelson L. Roray, Elmer Schuyler, Clyde H. Wady, E. K. Whiton, one incomplete solution. (14)
462. Norman Anning, Nelson L. Roray. (2)
463. Katherine S. Arnold, Richard S. Beardsley, Mabel G. Burdick, F. C. Gegenheimer, M. J. Leventhal, H. Polish, Nelson L. Roray. (7)
465. Norman Anning, three incorrect solutions. (4)

Total number of solutions, 48.

PROBLEMS FOR SOLUTION.

Algebra.

476. *Proposed by F. M. Phillips, Central College, Pella, Iowa.*

A tree 100 feet high, and standing in 12 feet of water, is broken so that the part broken off reaches from the stump to the ground, passing through the surface of the water 15 feet from the stump. Find the height of the stump.

477. *Proposed by Norman Anning, Chilliwack, B. C.*

In any scale of notation any multiple of m which has n digits remains a multiple after cyclic permutation of the digits, provided that m is a factor of the number formed by placing n 1's in a row.

Trigonometry.

478. *Proposed by R. T. McGregor, Bangor, Calif.*

A circle one foot in diameter is divided into three equal parts by two parallel lines. Find the distance between the parallels.

Geometry.

479. *Proposed by Edward Fleischer, Bushwick High School, Brooklyn.*

Through four given points pass four lines which shall form a square.

480. *Proposed by the editor. Sequel to 465.*

In the angle LOM are situated the fixed points A and B such that $AO = a$ and makes an angle α with OL, $BO = b$ and makes an angle β with OM. There is a shortest line from A to B touching both sides of the angle LOM. Find its length and show under what conditions it must touch OL first. Consider all cases for $\angle LOM < 180°$. Consider also other methods of constructing path than the one published under 465.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

223. *Proposed by R. E. English, Caldwell, Idaho.*

AB, the diameter of a semi-circular mirror ACB, is 12 in. P is a luminous point in the tangent at A. How far from A must P be placed so that a ray of light reflected at B and C will return to P? What is the length of the ray's path?

224. *Proposed by O. L. Brauer, Selma Union High School, Selma, Cal.*

Balance the equation, $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO + H_2O$, without making any assumptions as to intermediate reactions.

[A problem allied to Science Question 199, *Answer questions numbered 225 and 226 in the following lists.*]

BOARD-PHYSICS, 1915, Two Hours.

Group A. (*Omit one question from this group.*)

1. State the law of the conservation of energy.
   Explain how change of energy of one sort into energy of another sort is illustrated when a ball is thrown vertically upward.
2. A lump of metal weighs 160 grams in air, 140 grams in water, and 146 grams in oil. Find the specific gravity of the metal and that of the oil and also the volume of the metal.

3. A body weighing 120 pounds rests on an inclined plane, the length of which is 10 feet, the height 6 feet, and the base 8 feet.
Neglecting friction find:
a) The pressure which the body exerts perpendicular to the plane;
b) The force exerted parallel to the plane;
c) How much work must be done to move the body from the bottom to the top of the plane.

4. A windlass has a drum 6 inches in diameter and a crank arm 12 inches long.
Neglecting friction find:
a) What force applied to the crank arm is required to support a 100-pound weight;
b) What would be the efficiency of the windlass if a force of 30 pounds was found necessary to raise the weight.

GROUP B. (*Omit one question from this group.*)

5. How does sound differ from light in respect to
a) The nature of the medium required?
b) The character of the motion of the medium?
c) Velocity? (The approximate velocity of each should be given.)

225. A blow struck upon a steel cable was heard through the cable in 0.2 seconds and through the air in 3 seconds. The temperature was 0° C.
a) How far from the observer was the blow struck?
b) What was the speed of sound in the cable?

GROUP C. (*Omit one question from this group.*)

7. *a*) Why does sprinkling the floor with water cool the air?
b) Why is a clear night generally cooler than a cloudy one at the same season?
c) Why can you "see your breath" on a cold day?

8. When 1,000 grams of ice at 0° C. are put into 2,500 grams of water at 60° C. the temperature of the whole becomes 20° C. Find the heat of fusion of ice.

9. Neglecting loss of heat by radiation find how much steam at 100° C. is required to raise the temperature of an iron radiator weighing 60 kilograms from 10° C. to 100° C. (The specific heat of iron is 0.11.)

GROUP D. (*Omit one question from this group.*)

10. Explain by means of two diagrams, one showing the unaided eye and the other showing the eye assisted by a suitable lens, the effect produced by eye glasses which would enable a far-sighted person to see distinctly objects near at hand.

11. An object 1 foot high is placed 2 feet from a convex lens having a focal length of 18 inches.
a) Find the position and size of the resulting image.
b) Is the image real or virtual? Erect or inverted?

12. How may a distinct sun spectrum showing the Fraunhofer lines be obtained? How are the Fraunhofer lines explained?

GROUP E. (*Omit one question from this group.*)

13. Why do the leaves of a gold-leaf electroscope diverge when a positively charged body is brought near, although no charge passes from the charged body to the electroscope?
Indicate the distribution of the charge by means of a diagram.

14. Given a voltaic cell, a coil of wire, an ammeter, and a voltmeter, how may the resistance of the wire be determined?
Illustrate by means of a diagram the manner in which the apparatus is connected in the circuit employed.

15. Three voltaic cells, each having an electromotive force of 1.4 volts and a resistance of 0.1 ohm, are connected with a wire having a

resistance of 3.9 ohms. Find the strength of the electric current (*a*) When the cells are connected in series; (*b*) When the cells are connected in parallel.

The University of the State of New York (Regents).
212TH HIGH SCHOOL EXAMINATION

CHEMISTRY.

Tuesday, January 19, 1915—9:15 a. m. to 12:15 p. m. only.

GROUP I. (*Answer at least one question from this group.*)

1. Make a diagram of the apparatus used in the laboratory for the preparation and collection of hydrogen chloride [4]. Give *two* reasons for the method of collection [2]. Tell why *each* substance used was selected [2]. Mention *two* properties of the water solution of hydrogen chloride that are characteristic of acids [2].

2. Given the following compounds, state how you would identify *each* by chemical test: potassium chloride, ammonium sulphate, ferrous sulphide, lead nitrate, sodium bromide [10].

3. Give directions for the preparation of each of *three* allotropic forms of sulphur [6]. Which form is stable at (a) the temperature of boiling water [2], (*b*) 20° C. [2]?

GROUP II. (*Answer at least one question from this group.*)

4. Distinguish carefully between (*a*) symbol and formula [2], (*b*) acid salt and normal salt [2], (*c*) metal and nonmetal [2], (*d*) saturation and supersaturation [2], (*e*) solution and ionization [2].

5. Three of the oxides of nitrogen contain by weight respectively four parts of oxygen and seven parts of nitrogen, eight parts of oxygen and seven parts of nitrogen, and 20 parts of oxygen and seven parts of nitrogen. Show how the composition of these compounds illustrates the law of (*a*) definite proportions [4], (*b*) multiple proportions [6].

6. Select *five* elements and place *each* in its proper group and in its proper period to show that you understand the periodic law [10].

GROUP III. (*Answer at least one question from this group.*)

226. Find the number of liters of carbon dioxide that will result from the addition of sufficient hydrochloric acid to 100 grams of calcium carbonate [10]. [Atomic weights: C = 12, O = 16, Cl = 35.5, Ca = 40.]

8. Find the number of volumes of hydrogen and of nitrogen that enter into combination to form 200 liters of ammonia [10].

9. Express by chemical equations what takes place when (*a*) iron powder is heated with sulphur in a closed tube [2], (*b*) sodium reacts with water [2], (*c*) potassium chlorate is heated [2], (*d*) a water solution of chlorine is exposed to sunlight [2], (*e*) aluminum is treated with a water solution of sodium hydroxide [2].

GROUP IV. (*Answer at least one question from either this group or Group V.*)

10. Mention an important ore of lead [2]. Show how lead is extracted from the ore mentioned [2]. Mention (*a*) *two* common alloys of lead [2], (*b*) *two* uses of lead [2]. What are chrome yellow and white lead [2]?

11. Give in words the chemical composition of *each* of the following: quicklime, slaked lime, limestone, blue vitriol, caustic soda, lunar caustic, baking soda, washing soda, alum. How may the presence of the water of crystallization in alum be shown [10]?

12. Describe a commercial process of preparing sulphuric acid [4]. Mention *two* important physical properties and *two* important chemical properties of sulphuric acid [4]. Why are large quantities of sulphuric acid used in the manufacture of commercial fertilizers [2]?

GROUP V. *(Answer at least one question from either this group or Group IV.)*

13. What is a soap [2]? What is a hard water [2]? Mention *three* disadvantages in using hard water for washing [6].

14. Mention *two* food materials (*a*) rich in nitrogen [2], (*b*) rich in carbohydrates [2], (*c*) chiefly consisting of esters [2]. Mention *two* fruits or vegetables (*a*) valuable for their mineral contents [2], (*b*) used for the acids contained in them [2].

15. Describe *two* methods, one of which is agricultural, by which free nitrogen is converted into fixed nitrogen [10].

Solutions and Answers.

189. *Also answered by R. E. English, Caldwell, Idaho.*

Also solved by George Blanchard, Portland, Ore.

Concerning No. 204 in SCHOOL SCIENCE, March number, the correct answer is ⅓ of block in water, ⅔ in light liquid. Proof: Since block is suspended in the liquids the weight of liquids displaced equals weight of block. If ⅓ of block is in water then the weight of water displaced is ⅔ of weight of block. If ⅔ of block is in light liquid weight of lighter liquid displaced equals ⅓ of weight of block. Q. E. D.

208. *Also solved by A. H. Smith, Riverside, Cal.*

If the man were travelling from the source of the sound at the velocity of sound he would hear no sound at all. If he received any part of the sound wave it would not be a complete wave and therefore no sound would be heard. This follows from Doppler's Principle.

209. *Also solved by R. E. English.*

210. *From a Princeton Entrance Physics Paper.*

A rifle bullet leaves the muzzle of the rifle with a velocity of 750 meters per sec. The barrel is 80 cm. long. Assuming the acceleration to be constant, find its value in cm. Also find the time per sec. per sec. taken to traverse the barrel.

Solved by Carlton Pardee, 16, Riverside Polytechnic High School, Riverside, Cal.

Also solved by J. P. Drake, R. E. English.

$V = \sqrt{2as}$	$V = at$
$(75000)^2 = 2a(80)$	$75000 = 35{,}156{,}250t$
$5625000000 = 160a$	$t = .00213$ sec. *Ans.*
$a = 35{,}156{,}250$ cm. per sec^2.	

KENTUCKY ACADEMY OF SCIENCE.

The next meeting of this very important Association will be held in Lexington, Ky., May 6th. A very interesting and helpful program has been prepared. Dr. Forest Roy Moulton, the astronomer of Chicago University, will give an address. Many members of the Academy will read papers. All people living within the state who are interested in any phase of science should make plans to be present.

Dr. N. F. Smith of Centre College, Danville, is President.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany for February; *Brooklyn Botanic Garden; $4.00 per year, 50 cents a copy:* "The Exchange of Ions Between the Roots of Lupinus Albus and Culture Solutions Containing Three Nutrient Salts," Rodney H. True and Harley H. Bartlett; "On the Identity of Blanco's Species of Bambusa," E. D. Merrill; "The Region of Greatest Stem Thickness in Raphidophora," Frank C. Gates; "The Mechanism of Movement and the Duration of the Effect of Stimulation in the Leaves of Dionæa, William H. Brown.

American Mathematical Monthly for February; *5548 Kenwood Ave., Chicago, Ill.; $3.00 per year:* "A Tentative Platform for the Association," E. R. Hedrick; "Quantity of Matter in Dynamics," L. M. Hoskins; "Illustrations of Indeterminate Forms," W. V. Lovitt; "A Tribute to Walker Shattuck," G. A. Miller.

American Naturalist for April; *Garrison, N. Y.; $4.00 per year, 40 cents a copy:* "The Mechanism of Crossing-over," Hermann J. Muller; "Individual Differences and Family Resemblances in Animal Behavior," Halsey J. Bagg; "Evolution of the Chin," T. T. Waterman; "Hybrids of the Genus Epilobium," R. Holden.

Geographical Review for March; *American Geographical Society, Broadway, at 156 Street, New York City; $5.00 per year, 50 cents a copy:* "The Descent of the Rio Gy-Paraná" (one map, eight photos), Leo E. Miller; "Climatic Variations and Economic Cycles," (two maps, two diagrams), Ellsworth Huntington, Ph. D.; "Aridity and Humidity Maps of the United States," (two maps), Mark Jefferson; "Trade Movements and the War;" "Overcrowded Porto Rico;" "New Bathymetrical Charts of the Oceans," Ludwig Mecking.

Journal of Geography for April, *University of Wisconsin, Madison, $1.00 per year, 15 cents a copy:* "Some Problems in Geographic Education with Special Reference to Secondary Schools," R. E. Dodge; "Economic Geography: Its Growth and Possibilities," R. H. Whitbeck; "Geography in the Junior High School," Clara B. Kirchwey; "Work to be Done by the National Council of Geography Teachers;" "Lost Opportunities in Teaching Geography," Zonia Baber.

L'Enseignement Mathématique for January; *G. E. Stechert & Company, 151 West 25th St., New York; 15 francs per year, 2 francs a copy:* "Théorie de la Démonstration dans les Sciences Mathématiques" (42 pages), S. Zaremba; "A Propos d'une Récréation Arithmétique," M. d'Ocagne; "Des Equations Primitives Trinomes du Second Degré," H. E. Hansen.

National Geographic Magazine for February; *Washington, D. C.; $2.50 per year, 25 cents a copy:* "How Old Is Man?" (fifteen illustrations), Theodore Roosevelt; "The Cradle of Civilization" (twenty-three illustrations), James Baikie; "Pushing Back History's Horizon" (thirty illustrations), Albert T. Clay.

Nature Study Review for March; *Ithaca, New York; $1.00 per year, 15 cents a copy:* "Helen's Babies Christened," G. T. K. Norton; "The Present Trend of Nature Study in Wisconsin," Fred T. Ullrich; "Nature Study and the Common Forms of Animal Life, V," R. W. Shufeldt; "Educational Values of Children's Gardens," Alice J. Patterson.

Photo-Era for March; *383 Boylston St., Boston; $1.50 per year, 15 cents a copy:* "Methods of Exhibiting Color-Photographs," H. F. Perkins; "Airship-Photography in the War," Alexander Büttner; "Factors Which Influence Color in Printing-Out Paper," W. R. Henderson-Brockie; "The Nitrogen-Mazda Lamps," E. J. Wall; "Price-Cutting on Standard Photographic Products," A. H. Beardsley; "The Fixing-Bath Up to Date," E. J. Wall; "The End of the Quest" (a poem), William Ludlum, Jr.

Physical Review for March; *Ithaca, New York; $6.00 per year, 50 cents a copy:* "The Light Sensitiveness of Copper Oxide," A. H. Pfund; "The Characteristics of Tungsten Filaments as Functions of Temperature," Irving Langmuir; "On Ewell's Method of Measuring Single Potential Differences," S. J. Barnett; "A Mice X-Ray Spectrometer," W. S. Gorton; "A

Physical Study of the Thermal Conductivity of Solids," Arthur H. Compton; "On the Location of the Terminal Energy of Solids," Arthur H. Compton; "A Direct Phatoelectric Determination of Planck's 'h'," R. A. Millikan; "The Constants of Radioactivity," Gerald L. Wendt; "The Flourescing Sodium Uranyl Phosphate," H. L. Howes and D. T. Wilber.

Popular Astronomy for April; *Northfield, Minn.; $3.50 per year, 35 cents a copy:* "The History of the Discovery of the Solar Spots (Continued.," (with Plates IX and X), Walter M. Mitchell; "Nicolaus Copernicus," Charles N. Holmes; "The Distribution of Gaseous Matter Throughout Interstellar or Cosmic Space," Theodore William Schaefer, M .D.; "Mars and its Markings," Harry Hussey; "Some Interesting Aspects of the Siderial Universe," Henry H. McHenry.

Scientific Monthly for March; *Garrison, New York; $3.00 per year, 30 cents a copy:* "Plant Distribution in California," Douglass Houghton Campbell; "Industrial Research in America," Dr. Raymond F. Bacon; "The Present Status of the Antiquity of Man in North America," Dr. Clark Wissler; "Changsha and the Chinese," Dr. Alfred Reed; "On the Representation of Large Numbers and Infinite Processes," Dr. Arnold Emch.

Unterrichtsblätter für Mathematik und Naturwiss.nschaft, Nr. 1; *Otto Salle, Elssholzerstr. 15, Berlin W. 57, Germany; M. 4 per year, 60 Pf. a copy:* "Erdkunde und Krieg," Prof. Dr. Fritz Gräntz; "Amerikanische Kriegsarithmetik," Prof. Dr. Julius Ruska; "Ueber Sonnenuhren und ihre Anwendung im Unterricht," Prof. P. Kiesling; "Zur Lehre von den Aehnlichkeitspunkten dreier im Kriese," Prof. Jos. Moser; "Ein Einfacher Beweis des States von der Winkelhalbierenden Transversale des Dreiecks," Prof. Kiesling; "Ein Weiterer Beweis des Lehmus-Steinerschen Satzes," Prof. Kiesling; "Rückwärtseinschneiden aus zwei Punkten," Dr. Alois Lanner.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht Aller Schulgattungen for February; *B. G. Teubner, Leipsic, Germany; 12 nos. M. 12 per year:* "Die Mathematischen Reformbestrebungen," Prof. Dr. Pyrkosch; "Venus, 1916," Gymn.—Dir. Prof. W. B. Hoffmann; "Mittelpunktswinkel, Umfangswinkel, Sehne und Kreisviereck in Allgemeinster Behandlung," Oberlehrer Dr. Max Brües; "Ein Russisches Multiplikationsverfahren," Th. Meyer; "Neuer Beweis der Taylorschen Formel," C. Frenzel; "Irreführung durch Anschawng—Eine Anwendung der Logarithmenreihe—Elementare Berechnung der Sonnenmasse," H. Lerch; "Beweis für den Eulerschen Polyedersatz," H. Rübesamen; "Ableitung des Kosinussatzes," G. Olitsch.

ILLINOIS STATE ACADEMY OF SCIENCE.

Ninth Annual Meeting, Urbana.

One of the most successful meetings in the history of the State Academy was held Friday and Saturday, February 18th and 19th, in Urbana. About ninety speakers took part in the program. The topics covered included science in popular form which could be comprehended readily by the men on the street, and also technical papers so difficult as to make specialists in the line represented sit up and take notice; discoveries concerning microscopic animals, bacteria, fishes and birds; descriptions of flowers, as material as a grain of corn, and as large a flora as that represented by trees; the underground wealth of the state; the characteristics of the waters; interesting facts concerning the air—in short, things in the heavens and in the earth beneath were discussed by enthusiastic students.

The chief feature of the program was a symposium on astronomy—the first symposium on that subject which has been presented before the Academy. It was a popular discussion of the manner in which astronomers discover the distances of heavenly bodies where miles of infinite number

are measured with the accuracy employed by a carpenter in building a house. It is almost unbelievable that in measuring a million miles there would be an error less than that of two feet. The manner in which the heavens are photographed was explained.

Dr. W. G. Bain of St. John's Hospital, Springfield, explained a method whereby accurate scientific work done by men equipped with the best chemical, physical and medical knowledge results in giving reliable information in regard to the condition of a patient, so that the old methods of guesswork are no longer necessary. By Dr. Bain's plan, extensive analyses which ordinarily would require many hours' work can be made at a cost of about $5.00 per patient!

Dr. H. M. Whelpley of St. Louis as a guest of the Academy, in an interesting address on "The Landlords Whom We Have Evicted," showed some pictures of the celebrated Monk's Mound which is six miles east of St. Louis and which he characterized as the "largest monument built by prehistoric man." The curator of the State Museum, A. R. Crook, had in an earlier paper argued that the mound was a natural feature, all that was left of former deposits which formerly filled the valley and that the materials composing the mound at different levels agreed with those of the neighboring bluff three miles away and with materials of other mounds scattered over several miles. The materials are stratified and contain fossils, and the mounds are on a divide between two streams. Further, it is to be doubted whether Indians who were kept quite busy by the struggle for existence would have the time or the energy necessary to erect "the largest earth mound in existence," to say nothing of sixty smaller ones!

At a reception extended by the local branch of Sigma Xi, President James of the University, Dr. Farrington of the Field Museum; Professors Griffith of Knox College, Noyes of the University of Illinois, DeWolf of the State Geological Survey, and Washburn, Ward and Trelease of the University of Illinois, in a most attractive manner emphasized the value of the work of the Academy of Science, calling attention to the great service which the organization was performing and could render for people generally.

The newly elected officers are as follows:

President—William Trelease, University of Illinois.

Vice-President—H. E. Griffith of Knox College.

Secretary—J. L. Pricer of Normal.

Treasurer—Dr. H. S. Pepoon, Lake View High School, Chicago.

Member of Publication Committee—W. S. Bayley, Urbana.

Chairman of Membership Committee—A. R. Crook, State Museum.

A. R. CROOK.

A well-known citizen of Valparaiso, Mr. William E. Pinney, and his daughter, Myra, are establishing a Foundation for the training of young men in agriculture. It consists of four hundred acres of excellent land in the vicinity of Valparaiso. They have tendered the management of this Foundation to Valparaiso University, which the university gladly accepts. It will be the means of its enlarging to any extent desired its Department of Agriculture. The value of the Foundation is more than $50,000. Valparaiso University has never, in all its history, solicited any gifts or aid, and this is the first outside help, and is highly appreciated.

SAY BIGGEST SHADE TREE IS ALSO BEST.

That the largest shade tree in the United States, as brought to light by the prize contest held by the American Genetic Association, should turn out to be the eastern sycamore is not surprising, say Government foresters. The sycamore has long been regarded as the largest deciduous tree in North America and its range of growth is hardly second to that of any other broad-leaf tree; for it can be found from Maine to Florida, and as far west as Kansas.

The bestowal of the prize on a sycamore at Worthington, Indiana, which is forty-two feet, three inches, in circumference and 150 feet tall, draws attention to the fact that foresters are nowadays recommending the species, especially for city planting. They say that long experience with sycamores planted in city streets has shown that the species is peculiarly able to withstand the smoke, dust, and gases which are usually an unavoidable complement of urban life. In addition, the sycamore is as resistant to attacks of insects and fungi as almost any species, and is a quick grower; at ten years of age, a healthy sycamore usually is already large enough for shade as well as for decorative purposes. As for the latter, there is hardly any eastern species which is generally held so picturesque as the sycamore. With its strikingly mottled bark and magnificent stature and conformation, the sycamore has a marked individuality and can not be mistaken for any other species, either in the summer when the foliage conceals its structural form, or in the winter when the leaves are absent.

A common objection to the sycamore as a lawn tree is its habit of dropping its leaves before autumn. From this characteristic it is sometimes called a "dirty tree." Recently the Forest Service received a letter from a suburban resident who has a sycamore on his lawn. "My sycamore tree is very beautiful," said the writer, "until about the first of August, when its leaves begin to fall. Is there any remedy that I can apply to the tree to keep it from dropping its leaves so soon?" It was necessary to tell the correspondent that this was a characteristic habit of the tree. This drawback, however, is practically the only failing that the sycamore has, and it is offset by many desirable qualities.

On the other hand, there is little prospect of popularity, foresters say, for the valley oak of California, which was decided to be the largest nut-bearing tree in the United States, the contest unearthing a specimen in San Benito County, which was thirty-seven feet, six inches, in circumference and 125 feet high. The valley oak is a very beautiful tree, but it attains maturity only after three or four hundred years; its wood is too tough, knotty, and otherwise imperfect to be good for lum-

ber; the tree grows too slowly to be planted for shade or decorative purposes, and, being found only in California, it would have a small field of usefulness. Horticulturists say that the valley oak is not popularly considered a nut-bearing tree; for its acorns are not generally used for food, although, of course, they are edible. Foresters say that the chestnut and the black walnut are the largest nut-bearing trees in this country, and the contest did, in fact, unearth a chestnut near Crestmont, N. C., which is thirty-three feet, four inches, in circumference and about seventy-five feet tall.

The contest brought forth photographs and authentic descriptions of 337 trees in all parts of the United States, making a distinctly valuable contribution to existing knowledge of native trees. It was found that, in all probability, there is no living elm larger than "The Great Elm" at Wethersfield, Conn., which is twenty-eight feet in circumference and about one hundred feet tall, and is estimated to be 250 years old. Many remarkable specimens of species which ordinarily attain only small sizes were unearthed by the contest, furnishing new records of maximum growth. A sassafras was brought to light at Horsham, Pa., which is fifteen feet, ten inches, in circumference at four feet from the ground, whereas, for example, not long before this a Georgia town claimed that it had the largest sassafras tree in the world, though this tree was only something over seven feet in circumference. A white birch was found in Massachusetts with a girth of twelve feet, two inches; a pecan was found in Louisiana with a circumference of nineteen feet, six inches, and a catalpa in Arkansas with a girth of sixteen feet. The tallest tree found is a yellow poplar in North Carolina, which is 198 feet high and has a circumference of thirty-four feet, six inches.

The value of the contest lies in its contribution of new information as to the maximum growth attained by deciduous species and the localities in which the different species seem to grow best. The relative sizes of the coniferous species are fairly well established, the big tree of California, for example, being the largest in the world; but information on the size attained by deciduous trees in this country has been very incomplete.

HOME PROJECTS IN HIGH SCHOOL COURSES IN AGRICULTURE.

Many teachers of agriculture in high schools have felt that a wider use should be made of the home farm, both to give the pupil practical work with plants or animals, and to correlate more closely the activities of the class with the actual work of the home and farm. While many believe that there should be home projects in agriculture as a feature of every high school course in agriculture, the need for work of this sort at home is particularly important where the high school is not fortunate enough to possess a school farm.

To assist teachers in developing home projects in agriculture, the States Relations Service of the Department of Agriculture has recently issued Professional Paper No. 346, *Home Projects in Secondary Courses in Agriculture*. This bulletin discusses in detail the development of the home project idea and its use in various states where it has proved successful. This is followed by a discussion of the essentials of a home project in which are included directions for keeping records, blanks and forms, and typical outlines for projects on potatoes, pigs, alfalfa, orchards, poultry and the farm home. These home projects are classified as production, demonstration, improvement, and management projects, the last dealing with the business side of the farm. High school teachers of agriculture can obtain this bulletin free on application to the Editor and Chief, Division of Publications, U. S. Department of Agriculture, Washington, D. C., as long as the Department's supply for free distribution lasts.

CLASSROOM SAYINGS.

A Few New Ideas on Geometry.

Gleaned from Examination Papers of Candidates for Admission to the United States Naval Academy, by Walter C. Eells, U. S. Naval Academy.

A phombus is simply a square smashed down.

A secant is a straight line drawn from a point outside a circle, intersecting the circumference at some point, and approaching the circumference as its limit at another point.

A scalene triangle is a triangle, none of the angles of which are obtuse.

A scalene triangle is one with no angle as great or greater than a right angle.

A scalene triangle is one which has no definite shape.

A triangle drawn in an arc of 180° or one-half of a circle is called a scalene triangle.

A scalene triangle is a triangle drawn to scale and is used for measuring or enlarging a triangle.

Of isoperimetric figures the one which is smallest has the least area.

A segment of a circle is the part bounded by an *ark* and a *cord*.

Isoperimetric is a phrase or term applied to geometric figures having twenty sides.

"Owing to the fact that I am taking mumps, I beg to apoligize for these papers for somehow mumps are not at all favorable to the solution of mathematical problems. I trust that none of the examining committee will be infected by these mumps."

"An induced current may be produced by *reproaching* and receding magnet."

"The ohm is 106.3 cm. high."

"The Rhumkorff coil is one in which you place a battery inside another battery."

"The maximum thermometer consists of a tube with a bulb at the bottom and a fine bore. When it is heated, the liquid expands and pushes the bore up and the bore stays there when the liquid contracts."

"The oesophagus is a long, tortuous tube about 30 ft. long extending from the mouth to the stomach."

Q.: What is the effect of heat on matter? Give example.
Ans.: Heat expands and cold contracts. In summer it is hot and the days are long, but in winter when it is cold, the days contract.

Q.: It is common saying that lightning never strikes twice in the same place; what reason is there for this statement?
Ans.: Because after it hits once, the same place isn't there any more.

Q.: What kind of tube was used in the last experiment?
Ans.: A hollow tube.

Choice Extracts from a physiography examination in a large city high school:
Meander is a slow way of walking.
A levee is a tough district in Chicago.
A glacier is a piece of ice that was in North America once.
Omaha is a state just south of Wisconsin.
A barometer is a weather predicter made of a tube set in mercury.
The North American glazier was an immense mass of ice which came from Canada and floated down the Hudson River.

Q.: Describe the behavior of the tangent as the angle changes from 0° to 90°.
Ans.: The tangent increases from zero to infancy.

To rationalize this fraction you conjugate the denominator.

There is a class of student blunders that are tragic because the student knows enough to feel his argument correct yet not enough to understand the teacher's efforts to show the absurdity. Here is a sample:
Prove that if $f(x)$ be divided by $(x-a)$ the remainder is $f(a)$.
Proof:

$$\begin{array}{r|l|l} \underline{x-a} & f(x) & \underline{f} \\ & \underline{f(x)-f(a)} & \\ & \quad f(a), \text{ remainder.} & \end{array}$$

Will our readers kindly send to the Editor copy of curious classroom sayings which have occurred in their classes or on examination papers?

COURSES IN INDIAN SCHOOLS.

The Committee on Course of Study for the United States Indian Schools, recently convened by the Commissioner of Indian Affairs, Cato Sells, after several weeks' work in conference at Washington has completed a course of study which will give to the Indians the best vocational training offered by any school system in the United States.

As these schools must train Indian youth of both sexes to assume the duties and responsibilities of self-support and citizenship, this course strongly emphasizes vocational training.

It is divided into three divisions. The first is the beginning stage, the second the finding stage, and the third the finishing stage. During the first and second periods the training in domestic and industrial activities centers around the conditions essential to the improvement and proper maintenance of the home and farm. The course outlined in the prevocational division is unique in the fact that in addition to the regular academic subjects boys are required to take practical courses in farming, gardening, dairying, farm carpentry, farm blacksmithing, farm engineering, farm masonry, farm painting and shoe and harness repairing, and all girls are required to take courses in home cooking, sewing, laundering, nursing, poultry raising and kitchen gardening.

This course not only prepares the Indian youth for industrial efficiency but at the same time helps them to find those activities for which they are best adapted and to which they should apply themselves definitely during the vocational period, the character and amount of academic work being determined by its relative value and importance as a means of solving the problems of the farmer, mechanic and housewife.

Nonessentials are eliminated. One-half of each day is given to industrial training and the other half to academic studies. All effort is directed toward training Indian boys and girls for efficient and useful lives under the conditions which they must meet after leaving school. Other objects to which this course directs special attention are health, motherhood and child-welfare, civics, community meetings and extension work. —*Department of the Interior.*

A NEW EFFICIENCY BLANK FOR RATING TEACHERS.

Following the lines of thought in the modern schools of education, a form of a "graph" has been worked out to show the success or "efficiency" of teachers. The first practical or commercial use of such a graph has been made by the Clark Teachers' Agency. The experience of the managers (men with wide experience as teachers and also as agency directors) has led them to place the following topics on the blank as being, in their estimation, of primary importance—character, knowledge of subject matter, technique of teaching, governing skill, how does teacher work under supervision, interest in student activities (athletics debating, etc.), personal appearance, social qualities and disposition.

It so happens that these topics are almost identical with the ones decided upon by the students of the Department of Education in a large state university after a rather thorough investigation.

A glance at this blank tells all. The finest shades of difference can be expressed. It is predicted that blanks similar to the Clark blank will soon be in general use by all agencies and others who wish an easy, quick, accurate and understandable method of rating teachers.

The Clark Agency has very recently taken over the American Teachers' Agency in Knoxville, Tenn., and has arranged with David R. Kerr, Ph.D., LL.D., to take charge of the new office in Knoxville. Dr. Kerr has been for several years conducting a select school for girls. He was for many years president of Westminster College, Fulton, Mo., and of Bellevue College, Omaha, Neb. He is well known as a Presbyterian divine and as a lecturer in the educational field.

With seven offices, the Clark Teachers' Agency is equipped to give the most complete cooperative service.

LEAKAGE OF CURRENT FROM ELECTRIC RAILWAYS.

A study of the problems connected with the leakage of current from electric railways has recently been completed by the Bureau of Standards, Department of Commerce, and the results just published in Technologic Paper No. 63.

The theory of the leakage of current from electric railway tracks is developed mathematically, and curves are then plotted to aid in the interpretation of the results. The conclusions to be drawn from the formulas and curves are discussed with special reference to practical problems in electrolysis. It is shown how the escape of electricity from the rails is affected by increasing the track conductivity, as by careful bonding of all joints; by the use of a high resistance roadbed; and by shortening the distance over which a power house or substation furnishes power.

The paper is intended primarily for electric railway engineers and others familiar with electrolysis problems. Copies may be obtained free of charge by persons interested upon application to the Bureau of Standards, Washington D. C.

An average of ninety-five tons of soil and loose rock is washed into the ocean every year from every square mile of the United States, according to the Geological Survey. This estimate does not include the Great Basin. The immensity of this contribution may be better comprehended when it is realized that the surface of the United States covers 3,088,500 square miles.

TAKE CARE OF YOUR EYES.

Sight being quite as valuable as life itself, the admonition would seem to be unnecessary that the eyes should be scrupulously cared for. Yet, as a matter of fact, the waiting rooms of city and country oculists alike, are crowded, day after day and week after week, by people who have been criminally negligent of their vision. Reading too fine print, unleaded and often on glossy paper, is responsible for much of the mischief. Poor illumination is another destructive agency. Over-indulgence in tobacco or alcohol and reading too soon after recovery from an acute illness, play also a part in the throwing away of sight. One of the least excusable of agencies is the use of proprietary nostrums, both made and sold by men who know little or nothing about the eye, and, in addition, have never examined the eyes of the individual patient. These nostrums are generally advertised as "great discoveries," but consist of substances well known to educated oculists, and which are useful or harmful according to whether the person who employs them does or does not understand the diseases of the eye and the effects of medicines thereon in all their varying stages. Spectacles, too, are bought by many people who should know better, of quacks whose only education consists of a six weeks' correspondence course under the ignorant auspices of a diploma mill. The deplorable results are seen by educated oculists daily. The eye is, in fact, so valuable an organ, and is so frequently diseased in its deeper parts, while, externally, it seems to be absolutely sound, and, furthermore, is so frequently affected by the diseases of various other portions of the body, that no one should be entrusted either with its treatment or with its fitting by means of lenses, save those who have properly graduated from a first-class medical college, and, afterwards, have made a long, careful and scientific study of this priceless organ.

BOOKS RECEIVED.

Plain and Solid Geometry, by Webster Wells and Walter H. Hart, University of Wisconsin. Pages xii+467. 12.5x13 cm. Cloth. 1916. $1.30. D. C. Heath & Company, Boston, New York, and Chicago.

Students' Manual in Physical, Economical, and Regional Geography, by Charles E. Dryer and James A. Price of the Ft. Wayne High School. (Loose Leaf.) 171 pages. 19x24 cm. Paper. 1916. American Book Company, New York City.

Laboratory and Field Work in Zoology, by Robert W. Hagner, University of Michigan. Pages xiii+73. 13x19 cm. Cloth. 1915. 40 cents. The Macmillan Company, New York City.

Analytical Geometry, by W. A. Wilson and J. I. Tracy, both of Yale University. Pages xi+212. 12x18 cm. Cloth. 1915. D. C. Heath & Company, Boston.

Laboratory Problems in Civic Biology, by George W. Hunter, DeWitt Clinton High School, New York City. 283 pages. 14x21.5 cm. Cloth. 1916. American Book Company, New York City.

The Insect Notebook, by James D. Needham, Cornell University. 144 pages. 12.5x19 cm. Paper. 1916. 30 cents. Comstock Publishing Company, Ithaca, New York.

Animal Husbandry for Schools, by Merritt W. Harper, Cornell University. Pages xxiv+409. 13x19cm. Cloth. 1915. $1.40. The Macmillan Company, New York.

Solid Geometry, by William Betts, East High School, Rochester, and Harrison E. Webb, Central Commercial and Manual Training High School, Newark, N. J. Pages xxii+178. 13x18.5 cm. Cloth. 1916. 75 cents. Ginn & Company, Boston.

Cram's Junior Atlas of the World, by George F. Cram. 288 pages. 15x18.5 cm. Paper. George F. Cram, Chicago.

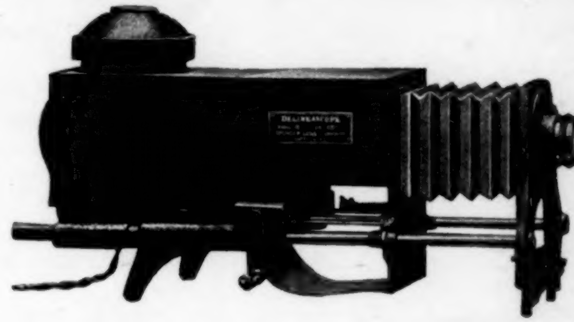
Journal of Proceedings, Fifty-third Annual Meeting, International Congress of Education. Pages xii+1193. 15x23.5 cm. Cloth. 1915. National Educational Association, Ann Arbor, Michigan.

Mathematische Bibliothek, Herausgegeben von W. Lietzmann und A. Wittung, von Prof. Alfred Leman, Oberlehrer an der Oberrealschule beim Kaiserpalast in Strassburg, i. e. 59 pages. 12x18.5 cm. Paper. 1916. M.80. B. G. Teubner, Leipzig.

Catalogue of High School and College Textbooks, Including a Complete Index and Price List, by Ginn & Company. Pages xxx—468. 13.5 x19.5 cm. Cloth. 1916. Ginn & Company, Boston.

STOVE AND CHESTNUT COAL IN GREATEST DEMAND.

Stove and chestnut sizes of anthracite coal are in the greatest demand and make up over forty per cent of the total shipments from the mines. They are essentially domestic sizes, and the relatively large proportion they make of the shipments serves as an index to the conditions governing the anthracite trade. Egg coal finds its way principally to the furnaces of residences, and pea coal is used in the same way to some extent, though it is also used for kitchen ranges and some of it goes with the buckwheat, and smaller sizes, for use as steam coal. The same sizes come directly into competition with bituminous coal and are sometimes used mixed with bituminous coal for generating steam, chiefly in hotels, apartment houses, and office buildings.



PANORAMIC VIEW OF MOUNT RAINIER NATIONAL PARK.

A panoramic view of Mount Rainier National Park, showing the characteristic features of the landscape, has just been issued by direction of Secretary Lane. This panorama shows in a striking manner the great central ice mass and the ridges that surround it. Ten colors were used in the printing, the ice being shown in light blue, the meadows and valleys in light green, the streams and lakes in blue, the cliffs and ridges in combinations of colors, and the roads in light brown. The lettering is printed in light brown, which is easily read on close inspection, but which merges into the basic colors when the sheet is held at some distance. This view, which may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for twenty-five cents, measures nineteen by twenty inches, and is on the scale of one mile to the inch. It is based on accurate surveys and gives an excellent idea of the configuration of the surface is it would appear to a person moving over it in an aeroplane.

BOOK REVIEWS.

Societal Evolution: A Study of the Evolutionary Basis of the Science of Society, by Albert G. Keller, Yale University. Pages xi+338. 13.5 x19.5 cm. Cloth. 1915. $1.50. The Macmillan Company, New York City.

A remarkable book, and one which should be read and studied by all persons who have any desire whatsoever to place humanity, in general, on a higher plane of social living. The volume will be eagerly read by all students of sociological problems. There is absolutely nothing but commendation to be given for the book. It is printed in heavy type on uncalendared paper, making it very easy to read. The style and diction are of the highest type. C. H. S.

Character and Temperament, by Joseph J. Strow, University of Wisconsin. Pages xviii—596. 14x20.5 cm. Paper. 1915. D. Appleton & Company, New York.

A book which people interested in psychology will gladly welcome to their libraries. It is written by a man who is thoroughly familiar with his subject, and he treats the work in a most interesting and educational manner. The statements and inferences are all authoritative. The volume is in a class by itself, standing out prominently, and should be read by every person interested in the science of psychology and the higher development of the human race. It is printed on uncalendared paper, thus reducing the glaring reflection of light to a minimum. C. H. S.

Outlines of Sociology, by Frank W. Blackmar, University of Kansas, and John L. Gillin, University of Wisconsin. Pages viii+586. 12.5x20.5 cm. Cloth. 1915. $2.00. The Macmillan Company, New York City.

Comparatively recently there has developed, and is now growing, an intense interest on the part of college and university people and those who are concerned in raising the standard of social living, a desire for books bearing upon the various phases of the science of society. This book has been written primarily for the purpose of meeting the requirements mentioned, and it gives the reader a very comprehensive view of the field of sociology. It is divided into seven parts under the following heads: "Nature and Import of Sociology," "Social Evolution," "Socialization and Social Control." "Social Ideals and Social Control," "Social Pathology,"

"Methods of Social Investigation," and "History of Sociology." There are altogether thirty-nine chapters, all of which close with a list of reference books bearing upon the principles discussed, with a list of questions pertaining to each particular chapter. The major paragraphs all begin with bold-faced type. The book is printed on uncalendared paper. There is also a bibliography of seven pages, and a splendid index. The statements made are all authentic, and make the volume one which should be a standard in its line, and of immense value to all progressive citizens. C. H. S.

Fundamental Sources of Efficiency, by Fletcher Durrell, Head of the Mathematics Department of the Lawrenceville School, Lawrenceville, N. J. 368 pages. 15.5x23.5 cm. Cloth. 1914. $2.65. J. P. Lippincott Company, Philadelphia.

Of the many remarkable texts which have recently come from the press, this indeed is one of the most notable. It is really a description of the new science of efficiency. The author shows a commendable knowledge of all phases of his theme, and has brought to bear in his discussions a wealth of information gathered from a wide range of reading and study. He has incorporated the material into such a working system that the ordinary layman or professional man will be able to increase his effective working capacity after reading and making a study of the methods presented. There are eighteen chapters, each closing with a long list of exercises which are suggested by the discussion in the chapter. Each major paragraph throughout the book has a heading of its own, so that the reader knows exactly what is being discussed as he goes through the book. Familiarity with the contents of this valuable work will save many people from making needless errors, and the information which they gather will enable them to become much more efficient. The volume deserves an extensive sale among those classes of people who are not only anxious to increase their own earning capacity, but who are striving to advance the efficiency of the world as a whole. C. H. S.

A Practical Elementary Chemistry, by B. W. McFarland, Ph.D., Assistant Principal and Head of Department of Science, New Haven High School, New Haven, Conn. Pages xvi+462. Illustrated. Cloth. 1915. $1.25. Charles Scribner's Sons.

This new high school chemistry text has many original features. Its principal thesis is that the work in chemistry should center around the laboratory work, which should precede the use of the descriptive part of the text. Many excellent teachers have been using this method with success for years, but without a textbook specifically designed for the purpose. Part I of the book is essentially a laboratory manual, containing forty-seven exercises. Part II contains the simpler part of the necessary chemical theory, and Part III the more advanced theory. Part IV is descriptive chemistry. The book gives promise of great usefulness in the hands of any teacher who has the necessary preparation and the needful time to give so intensive a course as the author designs. F. B. W.

Zoology, a Textbook for Universities, Colleges and Normal Schools, by Thomas Walton Galloway, Ph.D.,Litt.D., Professor of Zoology, Beloit College, late Professor of Biology in the James Millikin University. Third Edition. Revised with 255 illustrations. Pages xiii+546, 15x22 cm. $2.00. P. Blakiston's Son & Company.

This is a revision of a book well known to teachers of zoology. The book before us assuredly has very many good qualities. As an example of printer's art in bookmaking, it certainly is a success. The illustrations, the type, the paper, all are fine. The author has introduced many things

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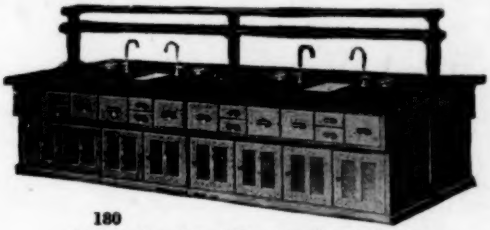

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which go to make a book teachable, such as "questions on the figures," many "summarizing" tables, black-faced type, "library exercises," suggestive studies for field and library, etc. Teachers will also appreciate the relegation of less important matter to finer type.

We like the author's statement of what he seeks to accomplish, in these two points especially—quoting from the preface—"the production and conservation of a vital interest in animals;" "the encouragement of the attitude of raising and solving problems concerning animals." To put it in other words, he aims to arouse an interest in animals and to stimulate the scientific attitude of mind in their study, two things which should consciously be in the mind of every teacher of zoology. We think Mr. Galloway has written a good book for the first year in college. W. W.

Handbook of Colloid Chemistry, by Dr. Wolfgang Ostwald, Privatdozent in the University of Leipzig. First English edition. Translated from the third German edition, by Dr. Martin H. Fischer, Professor of Physiology in the University of Cincinnati, with the assistance of Ralph E. Oesper, Ph.D., Instructor in Chemistry, New York University, and Louis Berman, M.D., Staff Physician, Mount Sinai Hospital, New York. Pages xii+278. 15x24.5x2 cm. Illustrated. Cloth. 1915. $3.00 net. P. Blakiston's Son & Company, Philadelphia.

The subtitle of this recent translation of an important work in one of the newer fields of science is "The Recognition of Colloids, The Theory of Colloids, and Their Several Physicochemical Properties." As the principal translator remarks in the preface, "The day is past when the importance of colloid chemistry to the worker in the abstract or applied branches of science needs emphasis. . . . . Whether we deal with the regions above the earth, as the color of the sky, the formation of fogs, the precipitation of rain and snow, or with the earth itself in its muddied streams, its minerals and its soils, or with the molten materials that lie under the earth, the problems of colloid chemistry are more to the fore than have ever been the crystalloid ones. . . . . It can only seem somewhat strange that three large German editions and seven years were required before its first issue in the tongue of Thomas Graham and the brilliant modern group of English-speaking colloid chemists."

The first twenty pages of the handbook are given over to a treatment of "Elementary General Colloid Analysis and Elementary Special Colloid Analysis." Then comes Part I on "General Colloid Chemistry." This part is divided into four chapters: Chapter I, on "The General Constitution of Colloid Systems;" Chapter II, on "Relation Between the Physical State and the General Properties of Colloid Systems;" Chapter III, on "General Energetics of Dispersoids;" and Chapter IV, on "Distribution of the Colloid State and the Concept of Colloid Chemistry."

Part II, on "Special Colloid Chemistry" has two chapters, the first (chapter V) on "Mechanical Properties of Colloid Systems," and the second (chapter VI) on the same topic. The four sections of these two chapters deal with: "I. Relations of Volume and Mass in Colloids;" "II. Internal Friction and Surface Tension of Colloids;" "III. Movement in Colloid Systems and its Results;" and "IV. Other Types of Movement in Dispersoids."

This handbook should furnish an admirable text for those who wish to begin a special study of colloid chemistry. Previously, such students have had to seek out what was needed in the literature, sometimes at great inconvenience, or have had to put up with the brief synopses furnished in textbooks of general and physical chemistry. The book is also a valuable reference book for any chemical library. F. B. W.

Catalogue of High School and College Textbooks, Including a Complete Index and Price List, by Ginn & Company. Pages xxx—468. 13.5 x13.5 cm. Cloth. 1916. Ginn & Company, Boston.

One of the most complete book catalogues that has ever come to this desk is the one published by the above firm. The bringing out of this fine volume shows commendable enterprise and business acumen on the part of these publishers. The method of binding gives one a sample of the splendid way in which the Ginn schoolbooks are put together. They are built to wear. Within the covers is found information of all kinds regarding any of the publications issued by this firm. There is a complete table of contents and an outline of their new and forthcoming publications. The main body of the book is of course devoted to a description of the works which they have already printed. Information such as is given in the heading of this review is found in connection with each of the books. Then follows a short description of the subject matter of each text. There are many half-tones and etchings scattered throughout the catalogue, giving one a sample of the york which is done in all of Ginn & Company's books. The texts are classified, so that it is an easy matter to turn at once to any book listed. There is a complete index and price list, together with the code words. All school men and people interested in schoolbooks in general will find this wonderful catalogue of great value. C. H. S.

Four Lectures on Mathematics, by J. Hadamard, Member of the Institute, Professor in the Collége de France and in the École Polytechnique. Pages 52. Paper covers. 1915. Columbia University Press, New York.

These lectures, delivered at Columbia University in the fall of 1911, extend into mathematics and physics. The titles of the lectures are as follows: "The Determination of Solutions of Linear Partial Differential Equations by Boundry Conditions;" "Contemporary Researches in Differential Equations, Integral Equations, and Integro-Differential Equations;" "Analysis-Situs in Connection with Correspondences and Differential Equations;" "Elementary Solutions of Partial Differential Equations and Green's Functions." H. E. C.

Die Funkentelegraphie, Dritte Auflage, by Oberpostpraktikant H. Thurn Pages 111. 13x18 cm. Geb. M. 1.25. 1915.

Statik, mit Einschluss der Festigkeitslehre, by Regierungsbaumeister A. Schau. Pages 144. Geb. M. 1.25. 1915.

These two very practical books have been recently published in the series, "Aus Natur und Geisteswelt," by B. G. Teubner. *Die Funkentelegraphie,* in three parts, "Drahtlose Telegraphie," "Drahtlose Telephonie," and "Einfluss der Funkentelegraphie auf den Wirtschaftsverkehr und das Verkehrsleben," gives a brief account of the invention and use of wireless telegraphy. In the first chapter is a discussion of the underlying physical principles—magnetism, electricity, capacity, induction, self-induction and so on; and the last two chapters give a number of statistical tables and other information regarding the use made of wireless telegraphy in transacting business throughout the world.

If students in engineering courses were required to use a few volumes of this series as books of reference there would be no need of a course in scientific German. *Statik* is very easy reading because it presents the subject in simple manner with many figures and worked-out problems. Beginning with simple problems in forces it carries the work through the works, roof construction, arches, and so on. H. E. C.
topics in the usual course in statics, with many applications to frame-